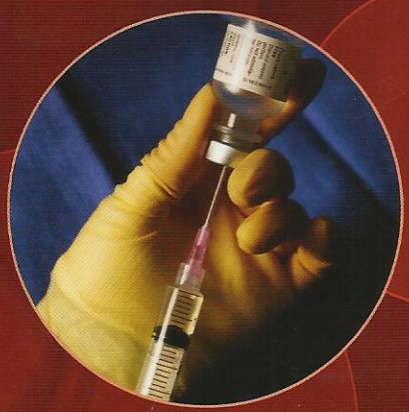
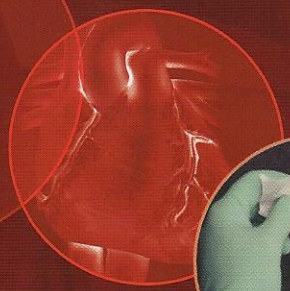
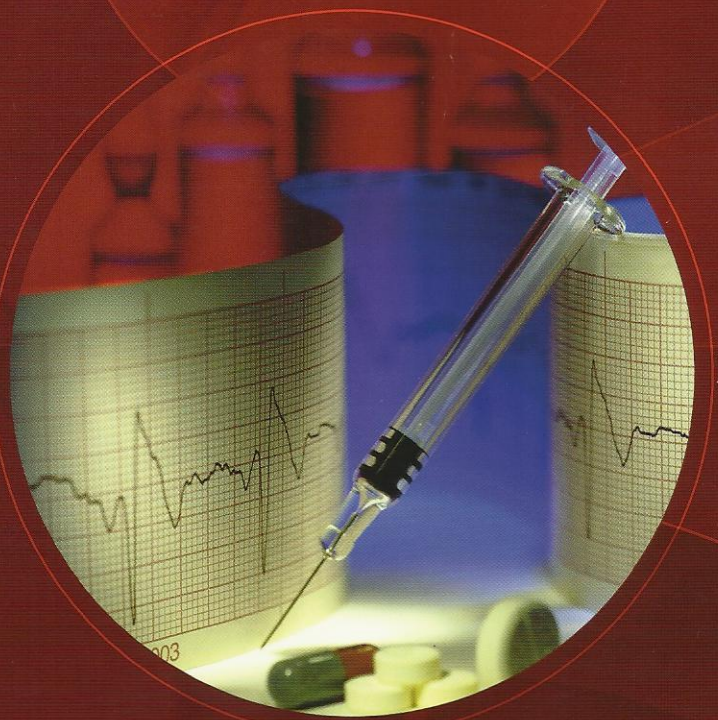
ECG & PHARMACOLOGY

American Heart Association®







ECG & Pharmacology

PROFESSIONAL

STUDENT WORKBOOK

American Heart Association®

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STUDENT WORKBOOK

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Contents

Part 1

ECG

Anatomy of the Heart

Anatomy of the Cardiovascular System

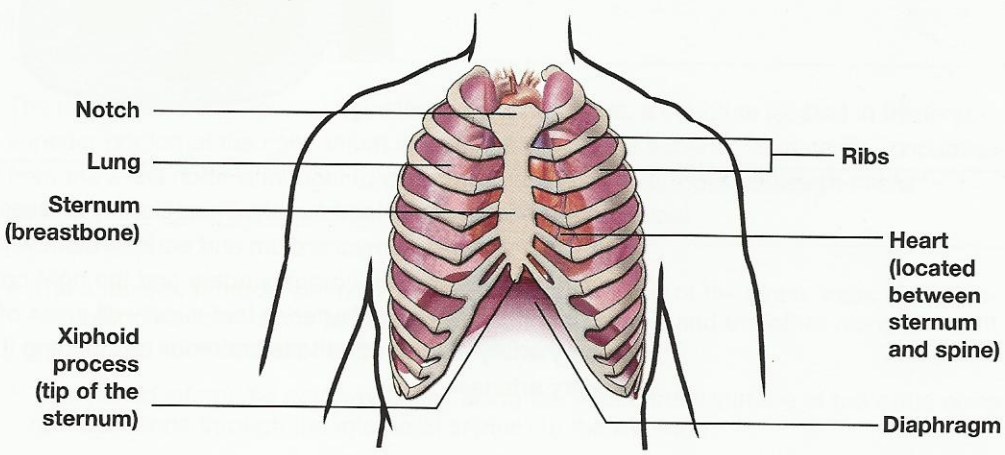
The cardiovascular system comprises the

- Heart
- Arteries
- Capillaries
- Veins

Heart

The heart of an adult is not much larger than a fist. It lies in the center of the chest, behind the breastbone (sternum), in front of the backbone (thoracic spine), and above the diaphragm. Except for the area against the spine and a small strip down the center of the front of the heart, the heart is surrounded by lung (Figure 1).

Figure 1. The heart in relation to other components of the chest.

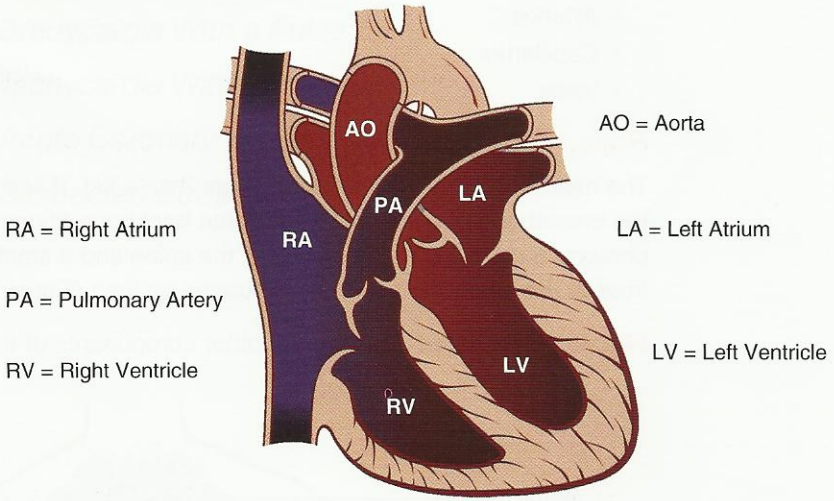


The heart is a hollow organ divided into 4 sections or chambers. The innermost layer of these chambers is called endocardium. The tough, muscular wall of the heart is called the myocardium (Figure 2). A sac called the pericardium surrounds the heart.

The following table describes the function of several parts of the heart.

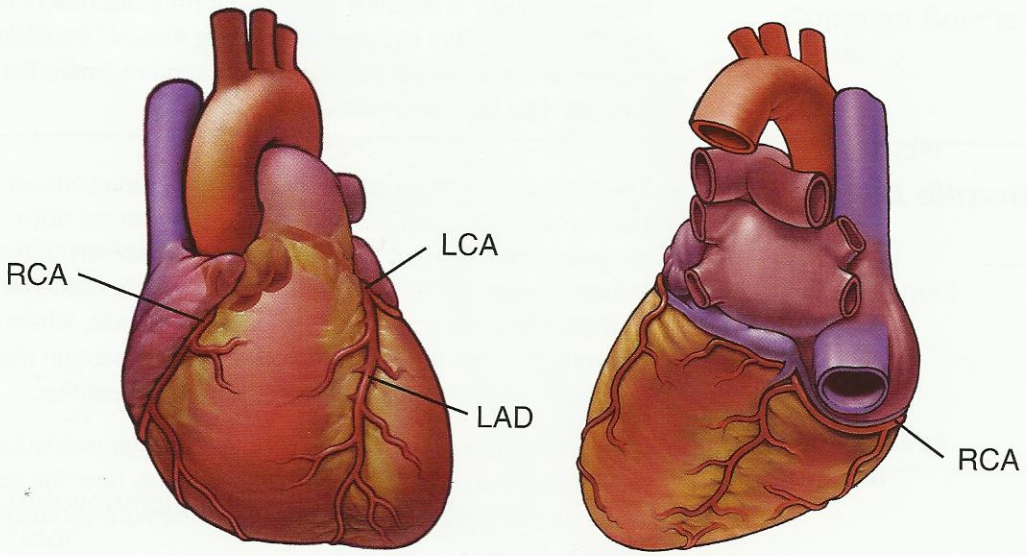
Part	Function
Right atrium	Receives blood from the body
Right ventricle	Receives blood from the right atrium. Pumps this blood into the pulmonary artery for delivery to the lungs
Left atrium	Receives oxygenated blood from the lungs
Left ventricle	Receives blood from the left atrium. Pumps this oxygenated blood into the aorta, supplying the body
Valves	• Located between the atria and ventricles and between the ventricles and the 2 major arteries (the pulmonary artery and the aorta) • Help maintain the forward flow of blood through the heart chambers and into the pulmonary artery or the aorta

Figure 2. The anatomy of the heart.



The heart has its own blood supply. The coronary arteries are the first branches of the aorta. They supply the myocardium and endocardium with oxygenated blood. The 2 main coronary arteries, the left coronary artery and the right coronary artery (Figure 3), branch into a complex network of arteries that supply all areas of the heart. The left main coronary artery divides into the left anterior descending (LAD) and left circumflex (LCX) coronary arteries.

Figure 3. The coronary arteries. RCA indicates right coronary artery; LCA, left coronary artery; and LAD, left anterior descending artery.



Cardiac contraction occurs first in the atria and then the ventricles. Atrioventricular synchrony contributes to normal function of the heart. Atrial contraction adds 15% to 20% to the cardiac output under normal physiologic conditions. However, an inherent delay in electrical activation of the ventricles is necessary for mechanical emptying of the atria to occur. The delay of the electrical conduction through the atrioventricular (AV) node allows time for the slower mechanical contraction to occur.

Conduction of the Heart

Sinus Node

The normal cardiac impulse originates in the sinus node, a structure located in the long, superior portion of the right atrium at its juncture with the superior vena cava. Conduction from the sinus node is thought to occur over internodal pathways, although this is controversial. Three internodal pathways are described below.

Atrial Conduction and Internodal Pathways

- The *anterior internodal pathway* arises at the cranial end of the sinus node. It divides into branches, one to the left atrium (Bachman's bundle) and the other along the right side of the interatrial septum to the AV node.
- The *middle internodal pathway* arises along the endocardial surface of the sinus node and descends through the interatrial septum to the AV node.
- The *posterior internodal pathway* arises from the caudal end of the sinus node and approaches the AV node at its posterior aspect.

The speed of conduction through the atria via these pathways is approximately 1000 mm/s.

Atrioventricular (AV) Node

The AV node is located inferiorly in the right atrium, anterior to the ostium of the coronary sinus and above the tricuspid valve. The speed of conduction is slowed (about 200 mm/s) through the AV node. The AV node is anatomically a complicated network of fibers. These fibers converge at its lower margin to form a discrete bundle of fibers, the *bundle of His* (or *AV bundle*). This structure penetrates the annulus fibrosis and arrives at the upper margin of the muscular intraventricular septum. There the bundle of His gives origin to the left and right bundle branches.

Bundle Branches

The *left bundle branch* arises as a series of radiations, or *fascicles,* at right angles to the bundle of His. A superior, anterior fascicle courses down the anterior aspect of the interventricular septum to the anterolateral papillary muscle, where it breaks up into a Purkinje network. The inferior, posterior fascicle is shorter and thicker, passing posteriorly to the base of the posteromedial papillary muscle, where it branches into the Purkinje network. Purkinje fibers to the interventricular septum may arise as a separate radiation or as fibers from either the anterior or posterior fascicles.

The *right bundle branch* courses down the interventricular septum on the right side. It contributes Purkinje fibers to the septum only near the apex of the right ventricle. At the lower end of the septum, it passes into the right ventricular wall, where it branches into a Purkinje network.

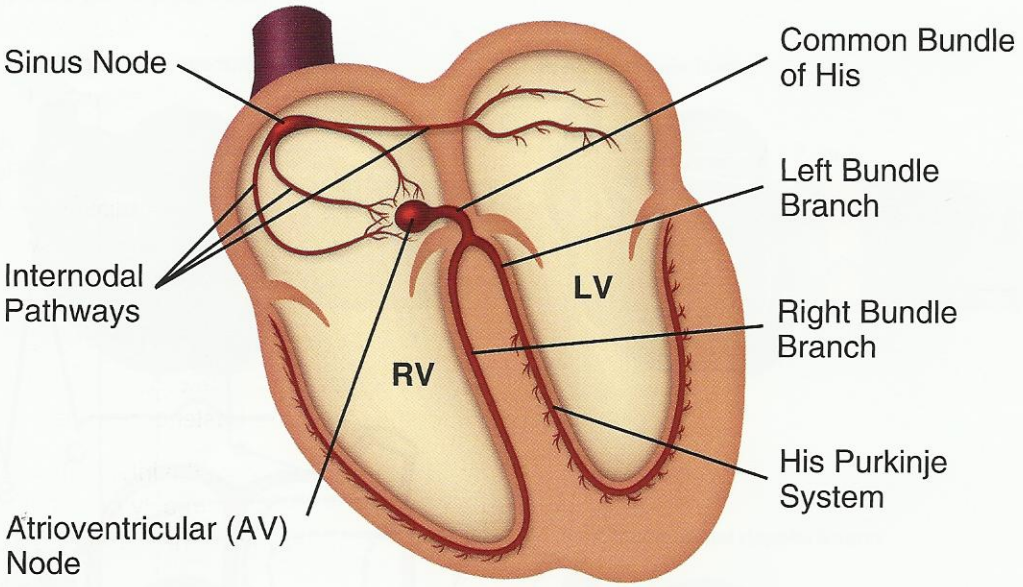
Ventricles

As the electrical impulse leaves the AV node, it passes into the bundle of His and then down the bundle branches simultaneously. The first section of the ventricles to begin depolarization is the mid portion of the interventricular septum from the left side, giving rise to the normal Q wave on the 12-lead ECG. The walls of the left and right ventricles are depolarized simultaneously. The speed of conduction through the ventricular Purkinje network is rapid, about 4000 mm/s. Conduction in ventricular muscle itself is considerably slower (about 400 mm/s).

Intrinsic Rates

Conduction Part	Rates
Sinus node	60 to 100 bpm
AV node	40 to 60 bpm
Purkinje fibers	15 to 40 bpm

Figure 4. The heart's conduction system anatomy.



ECG Components

The following table describes each ECG component and what it represents.

Component	Description	Represents
P wave	First upward deflection	Atrial depolarization
PR interval	Beginning of P wave to beginning of QRS complex	Time impulse takes to travel though the atria and AV node
QRS complex	Contains up to 3 waves: the Q wave, R wave, and S wave	Depolarization of ventricles
Q wave	First negative deflection after P wave	Depolarization of septum
R wave	First positive deflection following P or Q wave	Depolarization of ventricles
S wave	Negative deflection following R wave	Depolarization of ventricles
T wave	First upward deflection after S wave	Repolarization of the ventricles

Figure 5 shows the anatomy of the cardiac conduction system and its relationship to the ECG cardiac cycle.

Figure 5. Anatomy of the cardiac conduction system: relationship of cardiac cycle to conduction system anatomy.

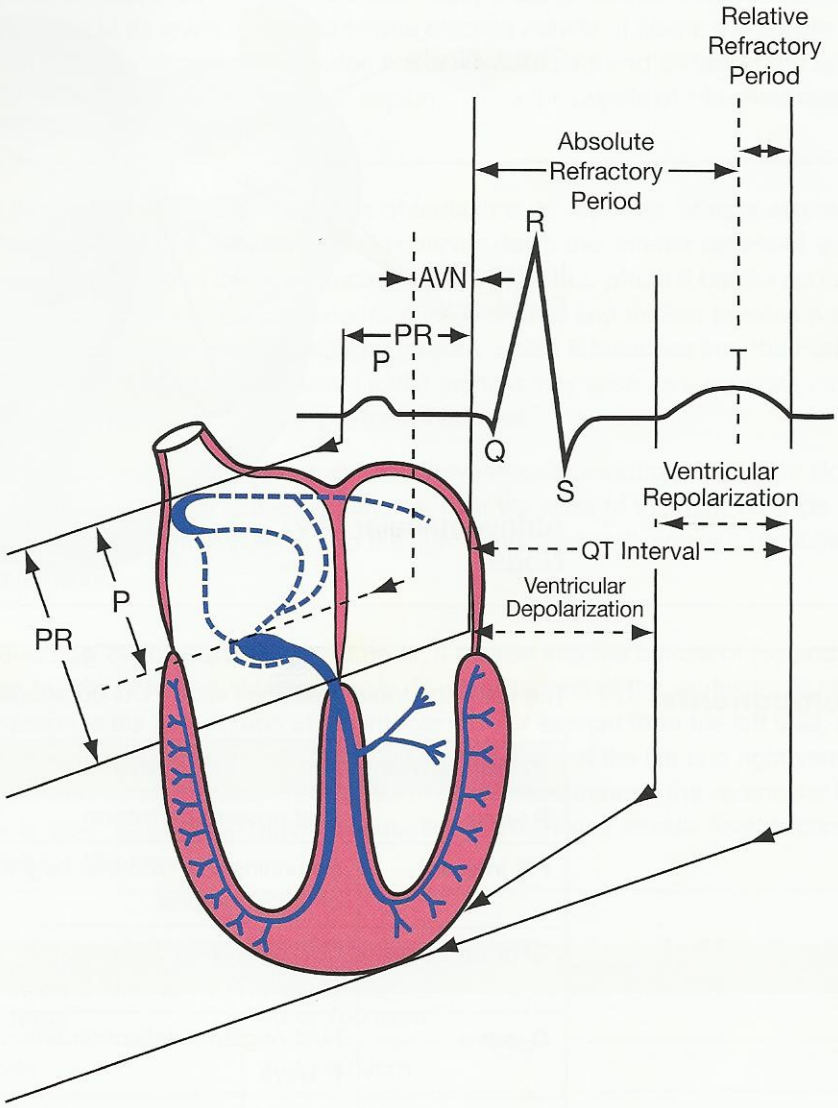
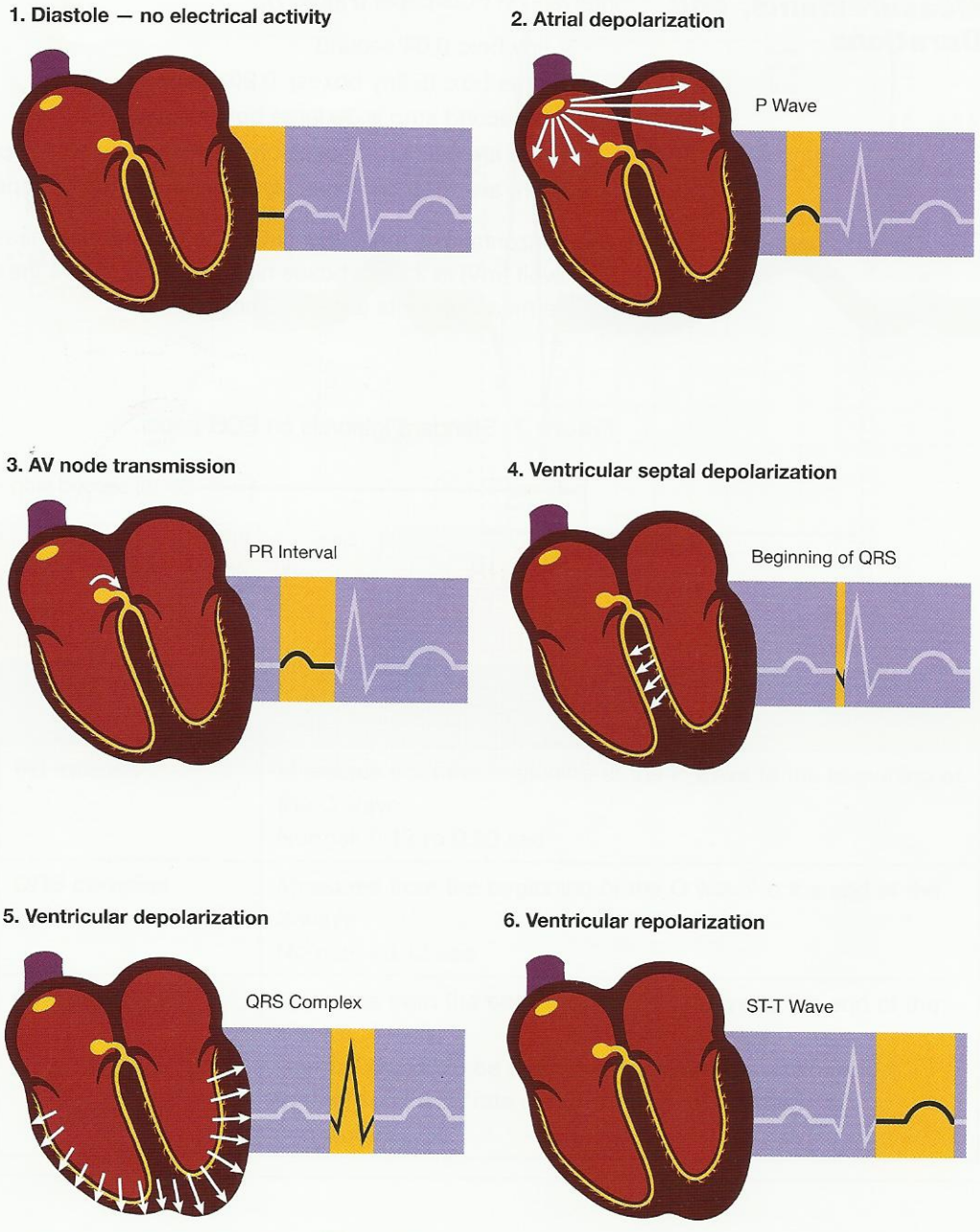


Figure 6. Rhythm indicators for electrical baseline (diastole), atrial depolarization, AV node transmission, ventricular septal depolarization, ventricular depolarization, and ventricular repolarization.



ECG Measurement

Major ECG Intervals, Measurements, and Durations

ECG paper usually moves at a speed of 25 mm/s. At that speed the following are standard intervals on ECG paper (Figure 7):

- 1 tiny box: 0.04 second
- 1 large box: (5 tiny boxes): 0.20 second
- A 6-second strip is 30 large boxes
- There are 300 large boxes on a 1-minute strip of paper
- There are 1500 tiny boxes in a 1-minute strip of paper

The horizontal axis measures time. The vertical axis measures voltage or amplitude. 1 millivolt (mV) is 2 large boxes high. Figure 8 shows the major ECG intervals and their normal measurements and durations.

Figure 7. Standard intervals on ECG paper.

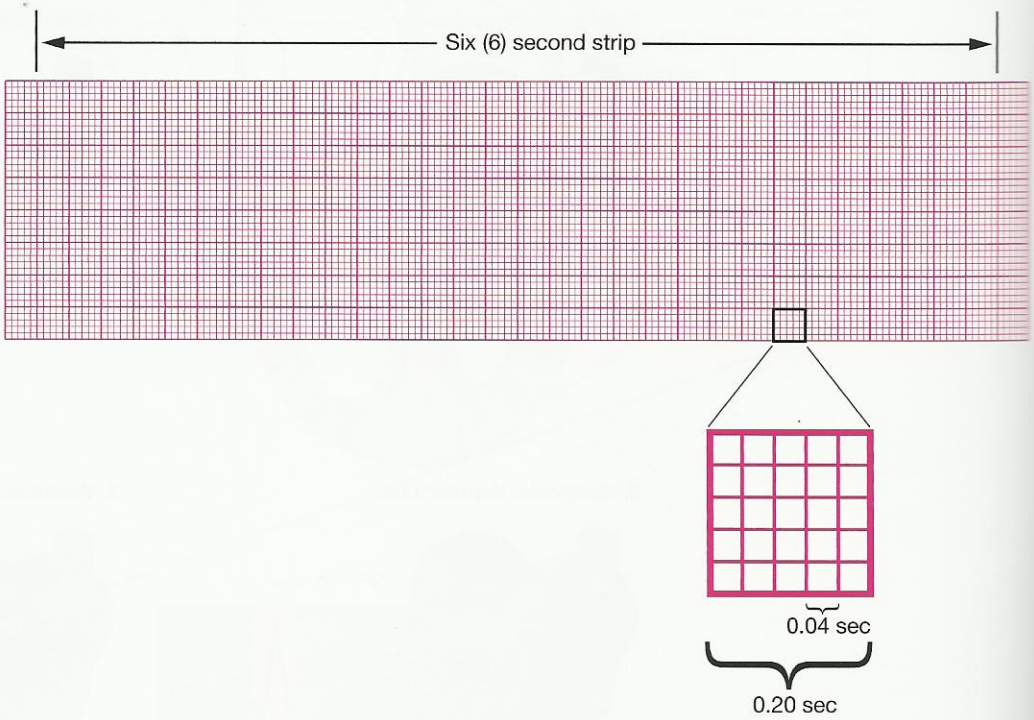
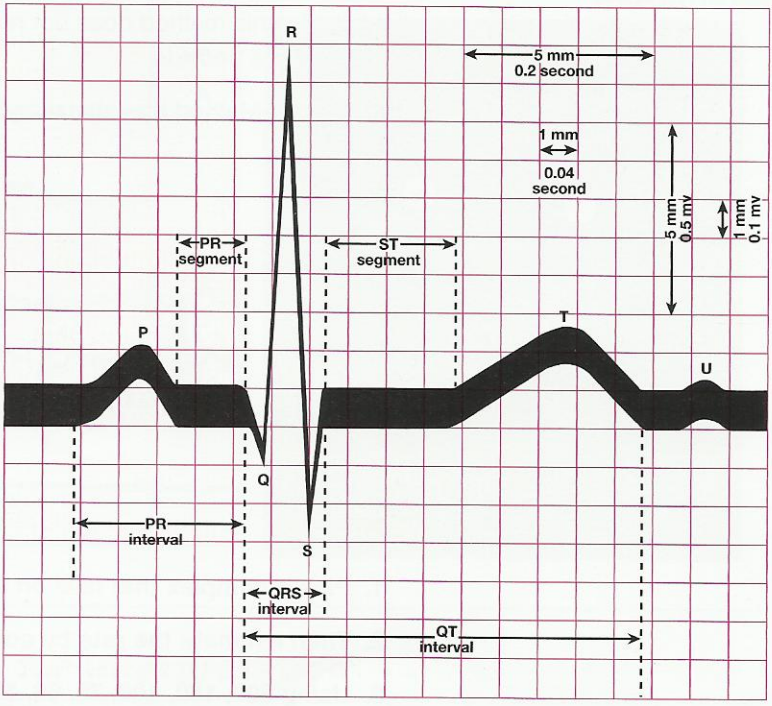


Figure 8. ECG measurements.

- **PR interval 0.12 → 0.20 s**
- **QRS complex <0.12 s**
- **QT interval Corrected for Heart Rate**

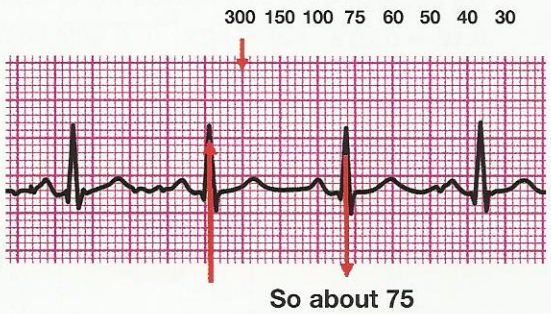


ECG Interval/ Complex	Measurement
PR interval	Measures from the beginning of the P wave to the beginning of the Q wave Normal: 0.12 to 0.20 sec
QRS complex	Measures from the beginning of the Q wave to the end of the S wave Normal: <0.12 sec
QT interval	Measures from the beginning of the Q wave to the end of the T wave Normal: Needs to be corrected for heart rate—usually 0.44 to 0.32 sec (heart rate of 60 to 100 bpm for both men and women)

Heart Rate Estimation

To estimate heart rate, memorize the rate intervals: 300, 150, 100, 75, 60, 50, 40, and 30. This method estimates heart rate (Figure 9). Although there are other methods and tools available, this method does not require a 3-second or 6-second strip and it can be used easily at the bedside.

Figure 9. Method for estimating heart rate.



1. **Pick a complex that falls on a heavy line**
2. **Then estimate the rate by counting heavy boxes**
3. **Using 300, 150, 100, 75, 60, 50, 40, 30**

Other heart rate measurements that can be used:

- Count the number of QRS complexes (R waves) on a 6-second strip and multiply by 10
- Divide 300 by the number of large boxes between 2 consecutive QRS complexes (R waves)
- Divide 1500 by the number of tiny boxes between 2 consecutive QRS complexes (R waves)

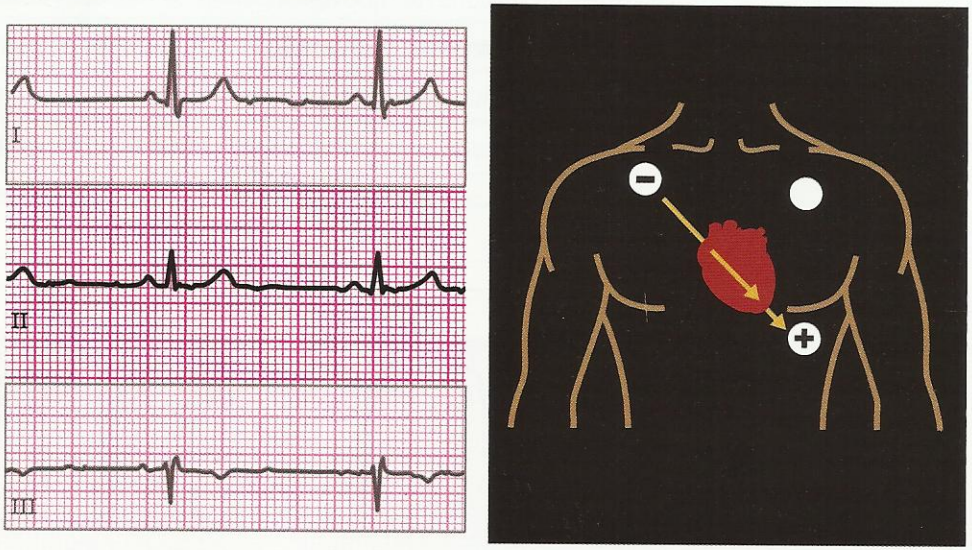
For atrial rate measurements, use the methods indicated above with P waves substituted for QRS complexes (R waves).

Normal atrial rate: 60 to 100
Normal ventricular rate: 60 to 100

Lead Placement

Figure 10 shows standard monitoring in lead II. Basic providers need to know only that the limb leads are "snapshots" of the 12-lead ECG. The leads differ in morphology and are not reliable as a diagnostic tool beyond monitoring. In this regard, it is important to obtain a 12-lead ECG for diagnostic purposes in a stable patient when a significant change in rhythm occurs. Similarly, a post-conversion 12-lead ECG should be done when a persistent rhythm abnormality resolves or is converted to a normal rhythm. These ECGs may be invaluable in the diagnosis of an abnormal rhythm.

Figure 10. Standard monitoring leads, lead II.



Rhythm Analysis: Four Questions for Interpretation

Overview

A standard, consistent, and routine approach to rhythm analysis is key to success. These 4 basic questions lead to correct analysis and diagnosis of the majority of rhythm abnormalities.

Step	Action
1	**Is the rate within the normal range** for a sinus-initiated rhythm?
2	**Is the rhythm regular or irregular?**
3	**Can P waves be identified?** Is there one P wave for each QRS complex? Does an impulse conduct the P wave and QRS complex in a 1:1 ratio?
4	**Is the QRS normal or wide?**

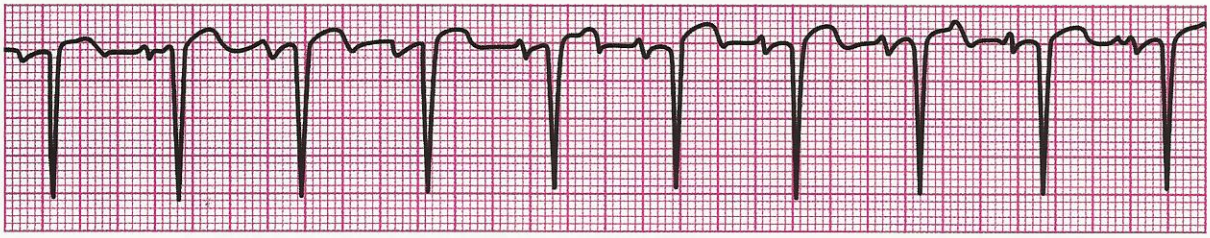
For healthcare providers, knowing the answers to these questions will allow them to navigate the appropriate algorithm and select the correct treatment or strategy.

Rhythm Strip Interpretation

This section contains sample rhythm strips. Use these to practice your rhythm strip interpretation skills.

Normal Sinus Rhythm

	Description
Atrial rate	Regular; P to P is regular, 60 to 100 bpm
Ventricular rate	Regular; R to R is regular, 60 to 100 bpm
P waves	P wave before every QRS complex
QRS	Unchanged unless aberrant conduction due to premature beat or increased rate
Intervals	• PR: 0.12 to 0.20 sec • QRS: <0.12 sec



Regular or irregular: _____

P waves present: _____

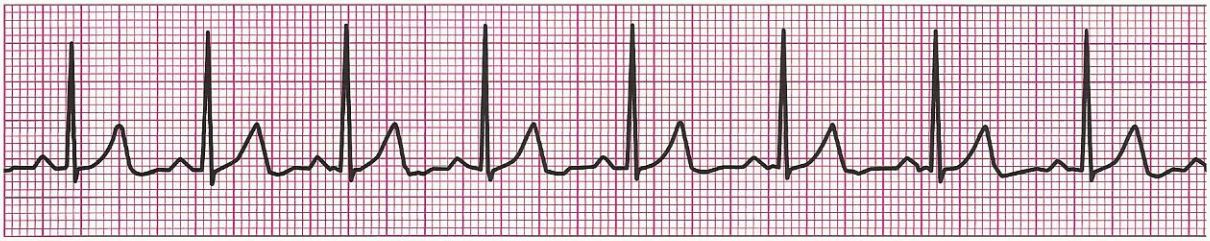
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

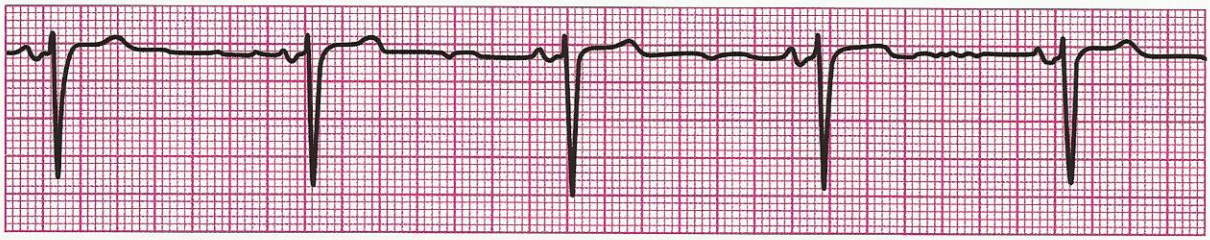
PR interval: _____

QRS interval: _____

Rhythm: _____

Sinus Bradycardia

	Description
Atrial rate	Regular; P to P is regular, <60 bpm
Ventricular rate	Regular; R to R is regular, <60 bpm
P waves	P wave before every QRS complex
QRS	Unchanged unless aberrant conduction due to premature beat
Intervals	• PR: 0.12 to 0.20 sec • QRS: <0.12 sec



Regular or irregular: _____

P waves present: _____

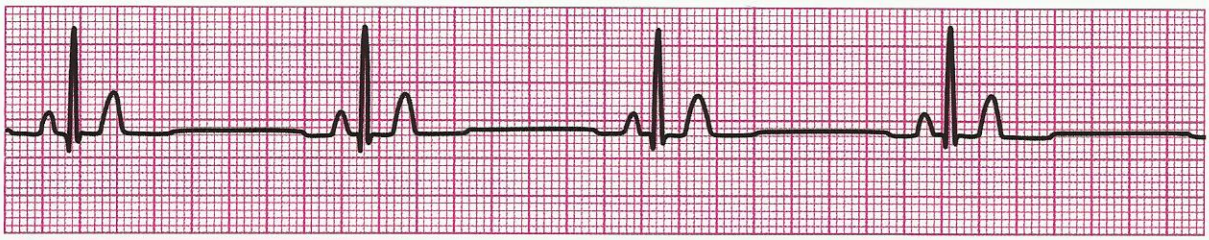
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

PR interval: _____

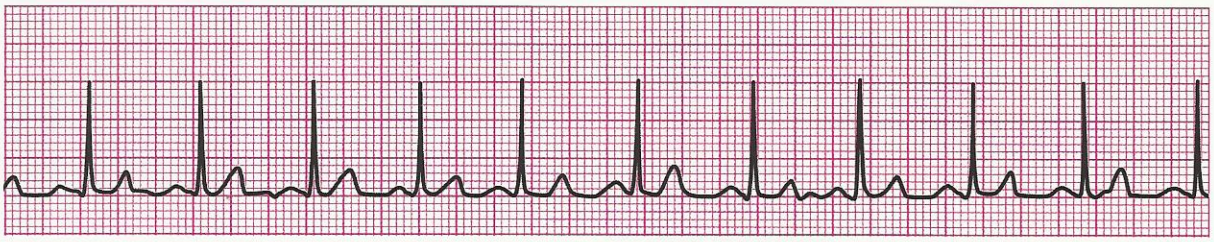
QRS interval: _____

Rhythm: _____

Sinus Tachycardia

Description

Atrial rate	Regular; P to P is regular, >100
Ventricular rate	Regular; R to R is regular, >100
P waves	P wave before every QRS complex
QRS	Unchanged unless aberrant conduction due to premature beat or increased rate
Intervals	• PR: 0.12 to 0.20 sec • QRS: <0.12 sec



Regular or irregular: _____

P waves present: _____

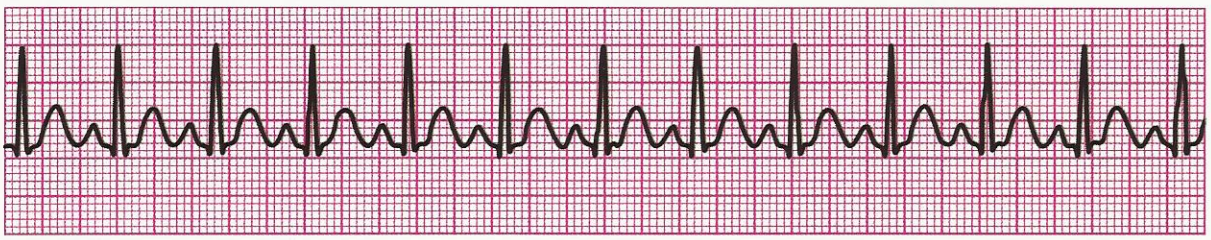
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

PR interval: _____

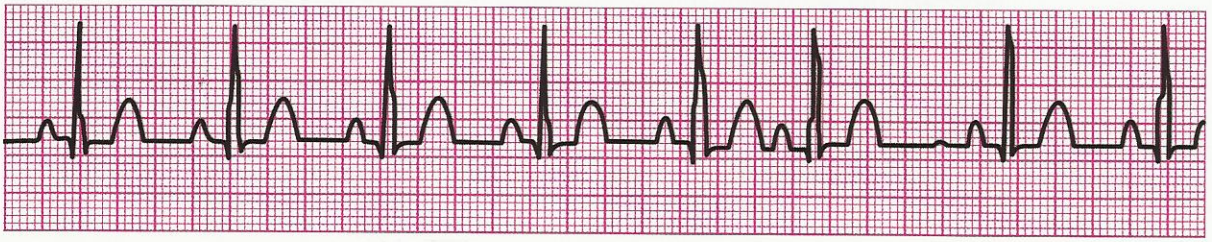
QRS interval: _____

Rhythm: _____

Premature Atrial Contraction (Complex)

Description

Atrial rate	Regular; P to P is regular, P to P shortens with PAC, rate depends on underlying rhythm
Ventricular rate	Regular; R to R is regular, R to R shortens with PAC, rate depends on underlying rhythm
P waves	P wave before every QRS complex; premature P wave usually different from sinus initiated complex.
QRS	Unchanged unless aberrant conduction due to premature beat or increased rate
Intervals	• PR: 0.12 to 0.20 sec • QRS: <0.12 sec



Regular or irregular: _____

P waves present: _____

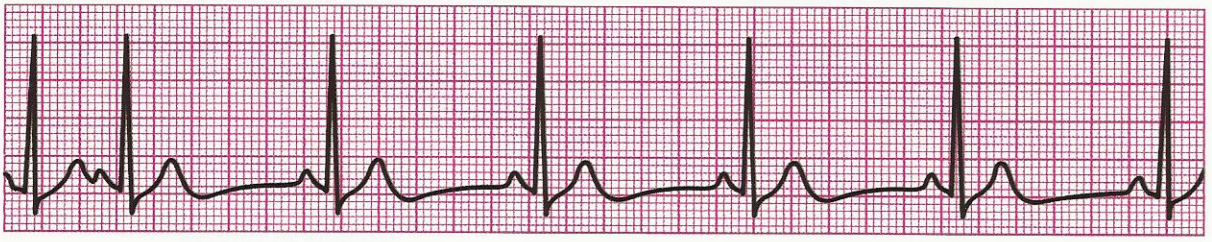
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

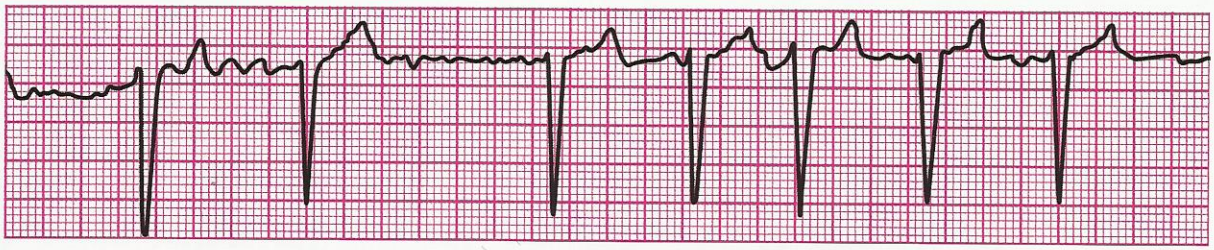
PR interval: _____

QRS interval: _____

Rhythm: _____

Atrial Fibrillation

	Description
Atrial rate	No P to P interval (no P waves, fibrillation "f" waves only), rate cannot be measured
Ventricular rate	R to R intervals are irregular, rate is variable—irregularly irregular
P waves	Small f waves create a wavy baseline
QRS	Unchanged unless aberrant conduction due to premature beat or increased rate
Intervals	• PR: not measurable • QRS: <0.12 sec



Regular or irregular: _____

P waves present: _____

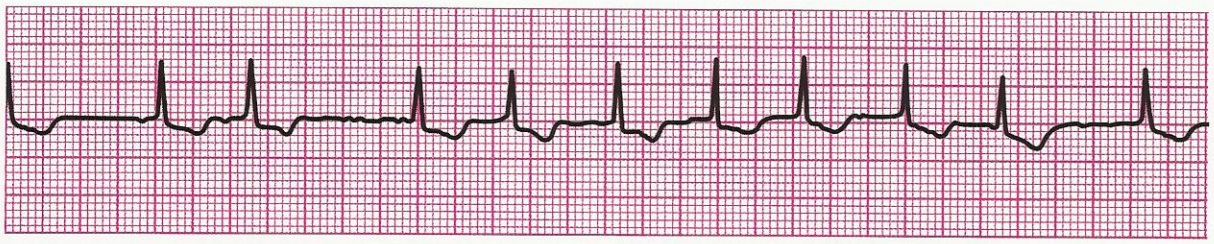
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

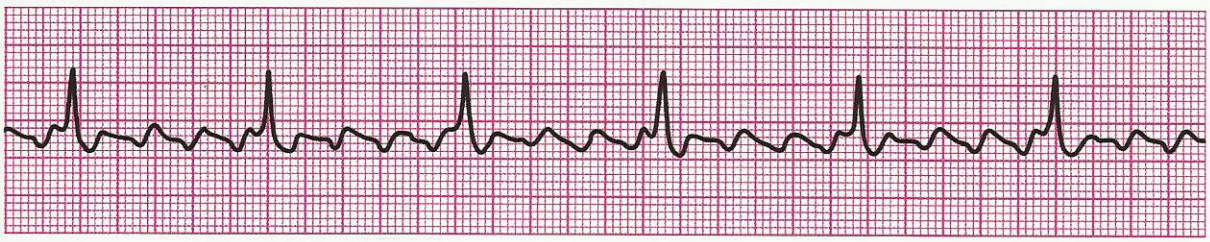
PR interval: _____

QRS interval: _____

Rhythm: _____

tter

	Description
Atrial rate	Regular; F to F is regular (no P waves—"F" or flutter waves), 250 to 400 bpm
Ventricular rate	R to R intervals are regular or irregular based on fixed or variable block, 60 to 150 bpm (usually 2:1 AV block)
P waves	Absent; more F's than QRS's. Flutter waves have sawtooth appearance.
QRS	Unchanged unless aberrant conduction due to premature beat or increased rate
Intervals	• PR: not measurable • QRS: <0.12 sec



Regular or irregular: _____

P waves present: _____

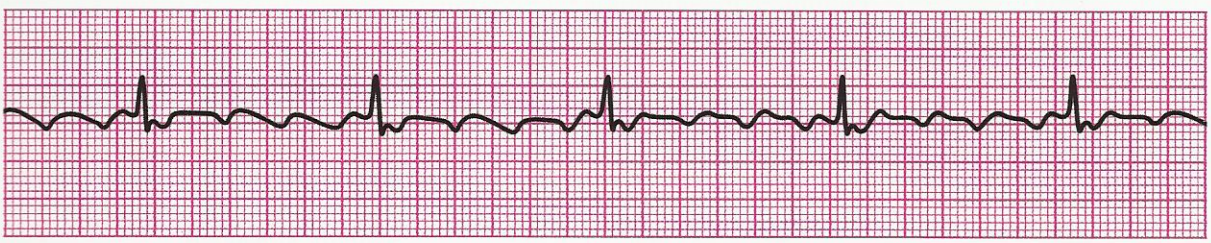
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

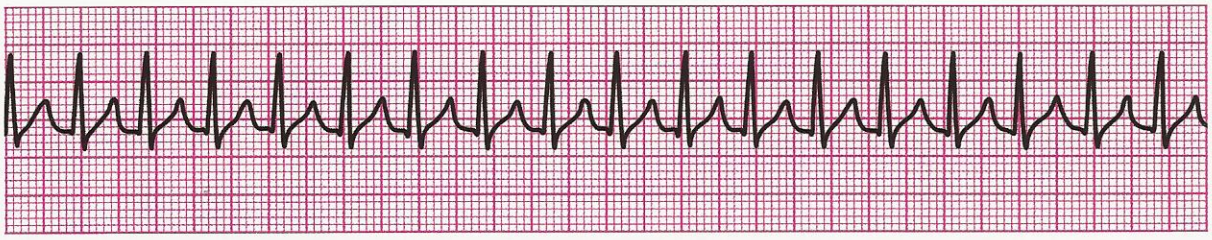
PR interval: _____

QRS interval: _____

Rhythm: _____

Supraventricular Tachycardia

	Description
Atrial rate	Regular; P to P is regular if P waves can be identified, 150 to 250 bpm
Ventricular rate	Regular; R to R intervals are regular, 150 to 250 bpm
P waves	Difficult to detect or hidden because of the fast heart rate
QRS	Unchanged unless aberrant conduction due to premature beat or increased rate
Intervals	• PR: not measurable • QRS: <0.12 sec



Regular or irregular: _____

P waves present: _____

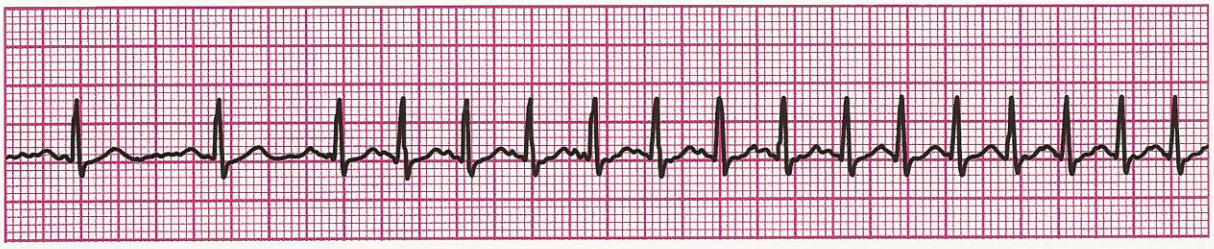
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

PR interval: _____

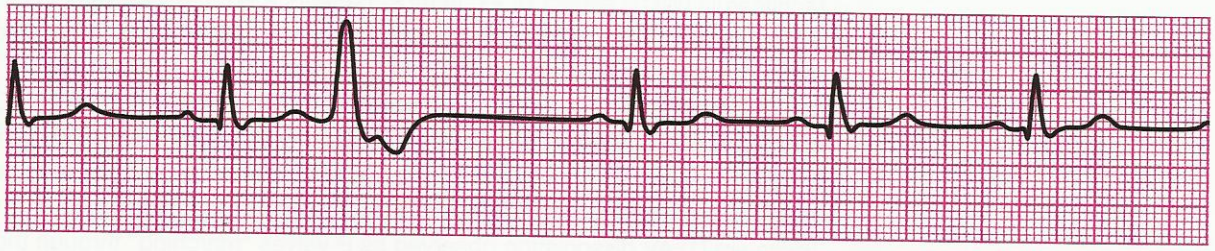
QRS interval: _____

Rhythm: _____

Premature Ventricular Contraction (Complex)

Description

Atrial rate	Absent or dissociated, rate depends on underlying rhythm
Ventricular rate	The R to R is shorter with ectopic beat, rate depends on underlying rhythm
P waves	Absent or dissociated from the ectopic
QRS	Widened or bizarre
Intervals	• PR: absent • QRS: ≥0.12 sec



Regular or irregular: _____

P waves present: _____

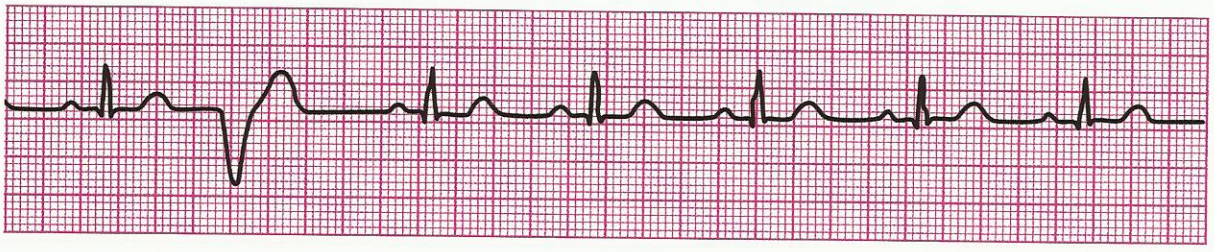
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

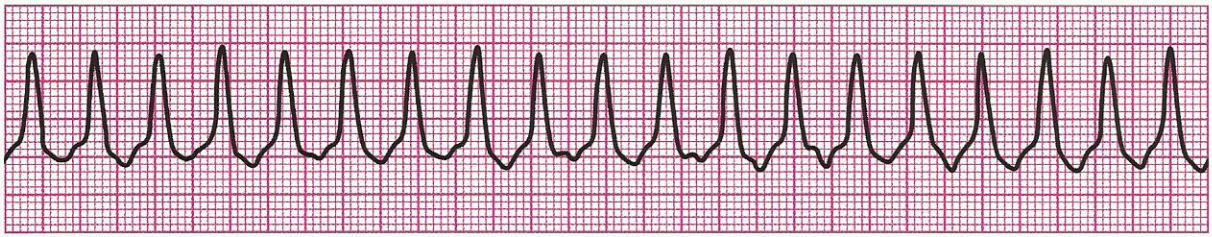
Rhythm: _____

Monomorphic Ventricular Tachycardia

Description

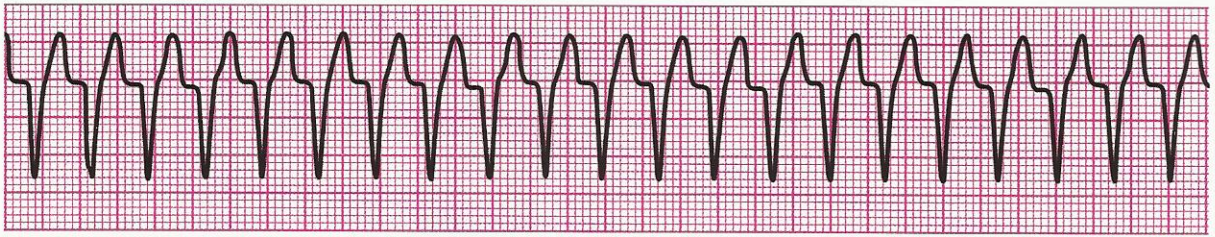
Atrial rate	Obscured (see discussion below)
Ventricular rate	Regular; R to R intervals are regular, >150 bpm
P waves	Obscured (see discussion below)
QRS	Wide and bizarre, unchanged unless aberrant conduction due to premature beat or increased rate
Intervals	• PR: absent* • QRS: ≥0.12 sec

* Learn More-Advanced ECG. The rhythm strip here emphasizes the regular wide complex tachycardia (WCT) aspect of VT. In most patients a WCT will be ventricular tachycardia, especially with older age and history of cardiac disease or acute chest discomfort. In these settings, presume and treat as VT. With advanced rhythm training, you will learn that WCTs may be abnormally conducted supraventricular rhythms and "look like" VT. Careful examination of a rhythm strip attempts to identify atrioventricular dissociation (not shown here). The atria in VT continue to contract in most instances, and the atrial and ventricular impulses are dissociated. This leads to the "footprints" identifying VT on rhythm strips. These are (1) AV dissociation observed as P waves "marching" through the wide complexes and occasional fusion or Dressler's beats. Fusion beats occur when the atrial contraction by chance conducts part of the QRS complex. This also is an indication of independent atrial depolarization and AV dissociation.



Regular or irregular: _____

P waves present: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

PR interval: _____

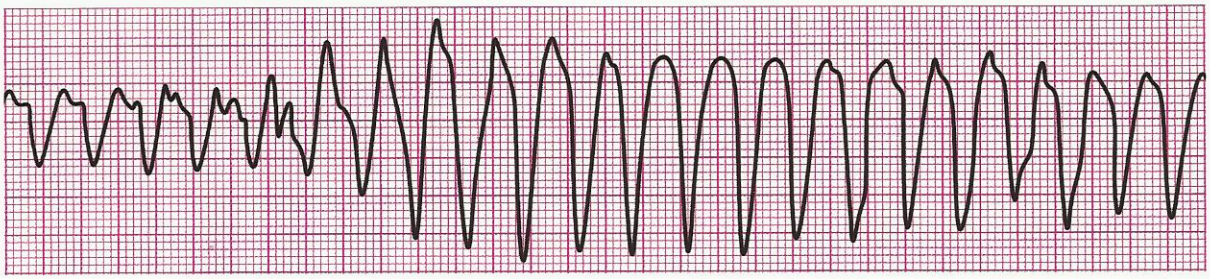
QRS interval: _____

Rhythm: _____

Polymorphic Ventricular Tachycardia

Description

Atrial rate	Obscured
Ventricular rate	Irregular and chaotic: 250 to 350 bpm
P waves	Obscured
QRS	Variable, wide and bizarre, not identical
Intervals	• PR: absent • QRS: ≥0.12 sec



Regular or irregular: _____

P waves present: _____

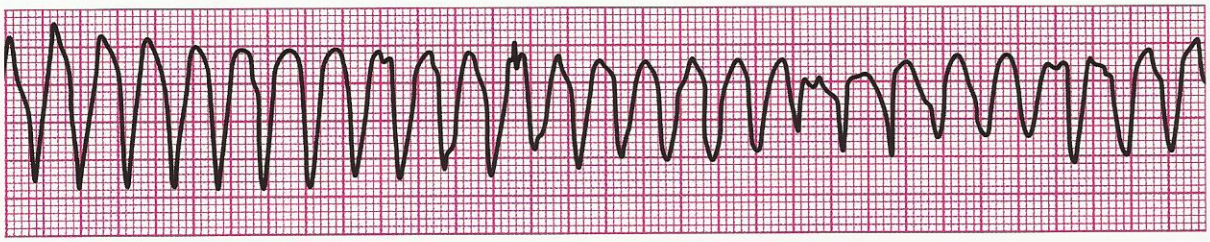
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

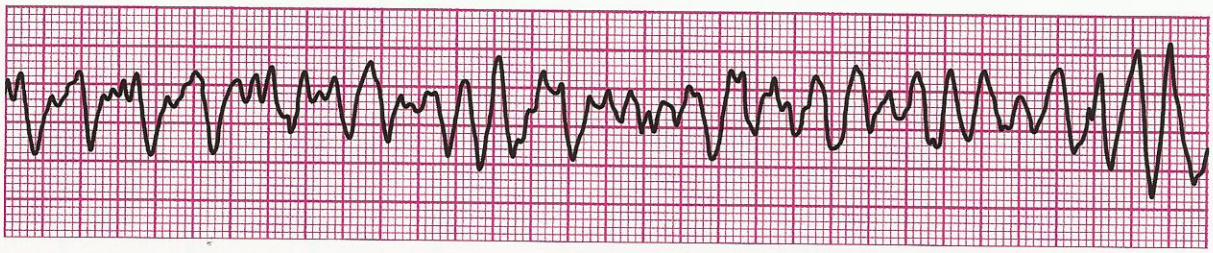
PR interval: _____

QRS interval: _____

Rhythm: _____

Ventricular Fibrillation

	Description
Atrial rate	Absent
Ventricular rate	Absent
P waves	Absent
QRS	Absent
Intervals	• PR: absent • QRS: absent



Regular or irregular: _____

P waves present: _____

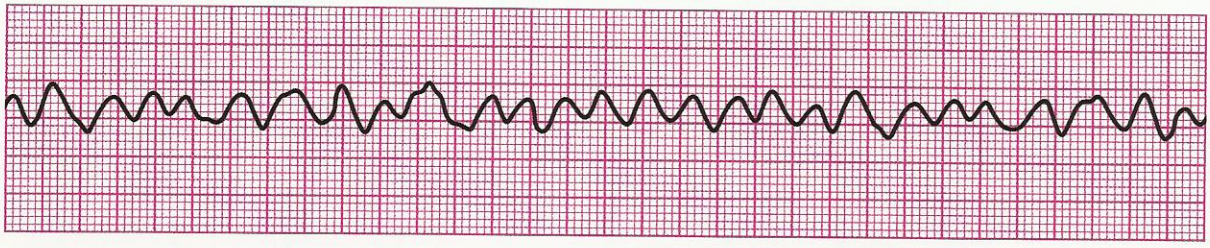
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

PR interval: _____

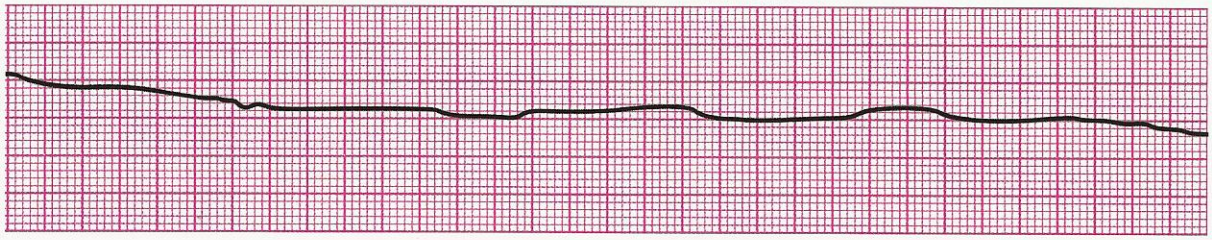
QRS interval: _____

Rhythm: _____

Asystole

Description

Atrial rate	Absent
Ventricular rate	Absent
P waves	Absent
QRS	Absent
Intervals	• PR: absent • QRS: absent



Regular or irregular: _____

P waves present: _____

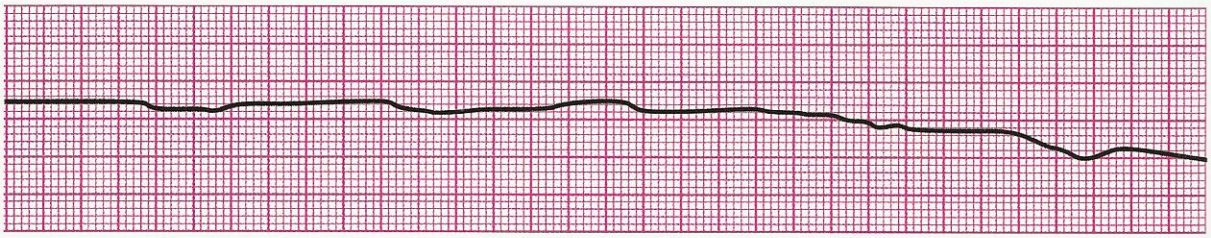
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

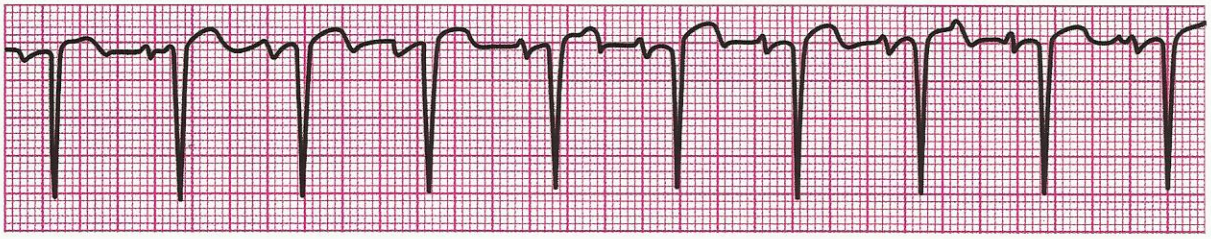
Atrial rate: _____

Ventricular rate: _____

*Pulseless Electrical Activity**

	Description
Atrial rate	Variable
Ventricular rate	Variable
P waves	May be present or absent
QRS	Variable
Intervals	• PR: may be present or absent • QRS: variable

*Although referred to as a "rhythm," PEA can be one of several rhythms that share a common feature—lack of a clinically detectable pulse. By definition PEA is any organized rhythm without a pulse, so the monitor or ECG characteristics are variable.



If no pulse with this rhythm?

Regular or irregular: _____

P waves present: _____

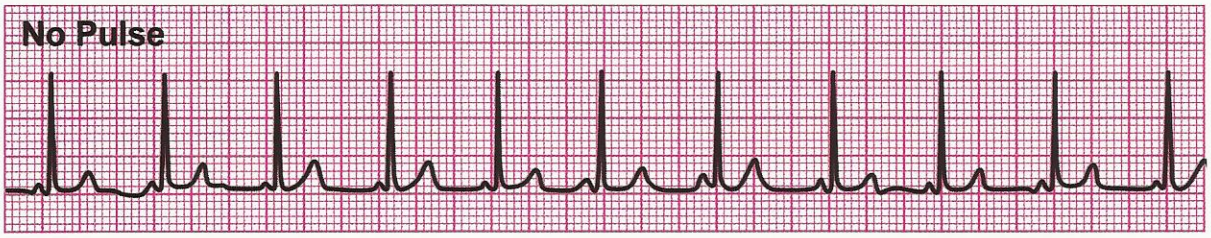
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

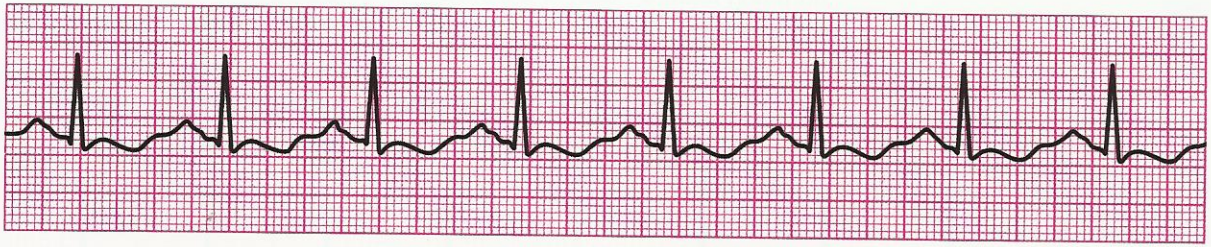
PR interval: _____

QRS interval: _____

Rhythm: _____

First-Degree Block

	Description
Atrial rate	Regular; P to P is regular, 60 to 100 bpm
Ventricular rate	Regular; R to R is regular, 60 to 100 bpm
P waves	P wave before every QRS complex
QRS	Unchanged unless aberrant conduction due to premature beat or increased rate
Intervals	• PR: >0.20 sec • QRS: <0.12 sec



Regular or irregular: _____

P waves present: _____

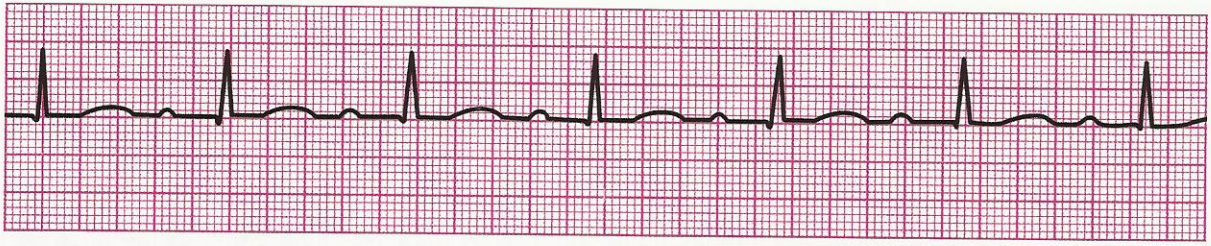
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



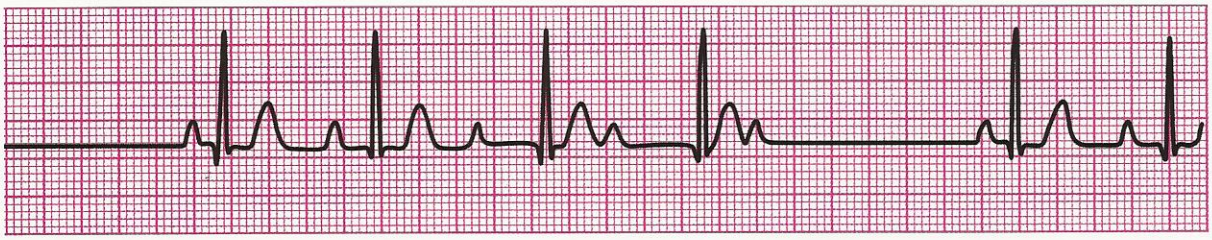
Regular or irregular: _____

P waves present: _____

Second-Degree Block (Type I)

Description

Atrial rate	Regular; P to P is regular, 60 to 100 bpm
Ventricular rate	R to R intervals tend to decrease progressively; until QRS is dropped, rate is variable
P waves	More P waves than QRS complexes
QRS	Unchanged unless aberrant conduction due to premature beat or increased rate, but dropped in a cyclic pattern
Intervals	• PR: increase with each beat • QRS: <0.12 sec



Regular or irregular: _____

P waves present: _____

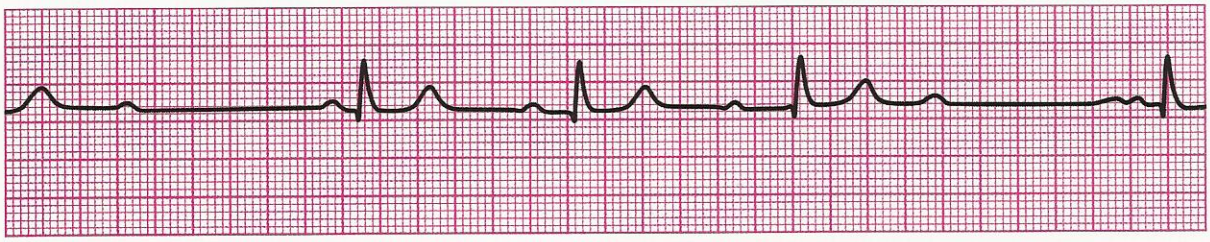
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

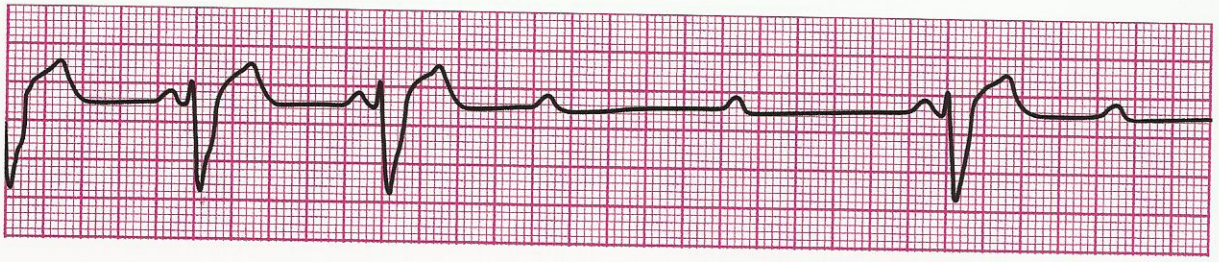
PR interval: _____

QRS interval: _____

Rhythm: _____

Second-Degree Block (Type II)

	Description
Atrial rate	Regular; P to P is regular, rate is variable
Ventricular rate	Regular; until QRS is dropped, rate is less than atrial rate
P waves	More P waves than QRS complexes
QRS	Unchanged unless aberrant conduction due to premature beat or increased rate
Intervals	• PR: 0.12 to 0.20 sec where they can be measured • QRS: variable



Regular or irregular: _____

P waves present: _____

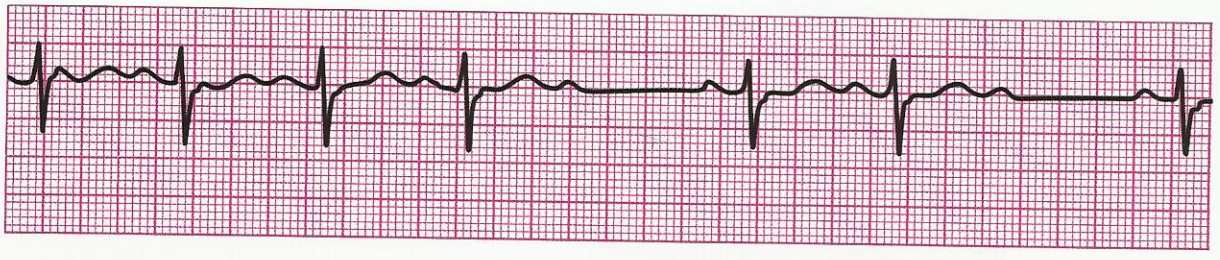
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

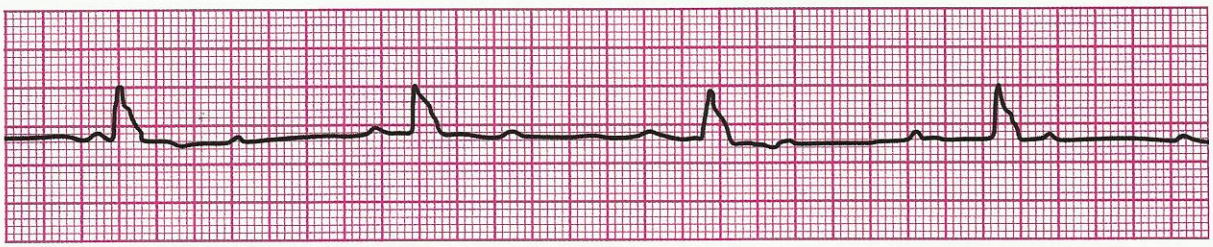
PR interval: _____

QRS interval: _____

Rhythm: _____

Third-Degree Block

	Description
Atrial rate	Regular; P to P is regular (if underlying rhythm sinus), 60 to 100 bpm, can be variable (eg atrial fibrillation)
Ventricular rate	Regular; R to R is regular, ≤60 bpm (40 to 60 bpm if junctional, 15 to 40 bpm if ventricular)
P waves	More P waves than QRS complexes (Complete A-V dissociation)
QRS	Unchanged unless aberrant conduction due to premature beat or increased rate
Intervals	• PR: increase with each beat • QRS: variable, but usually >0.12 sec



Regular or irregular: _____

P waves present: _____

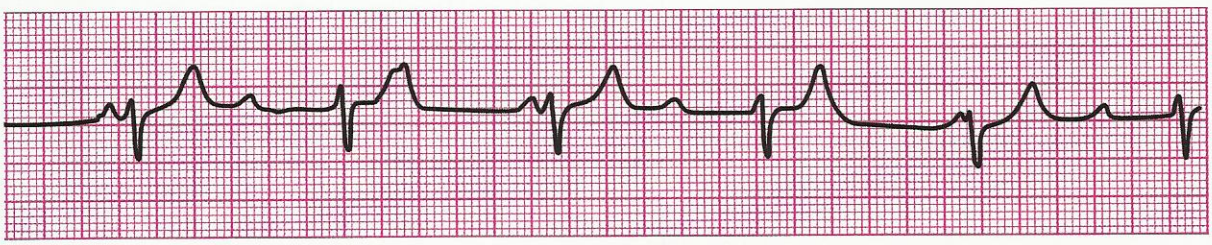
Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____



Regular or irregular: _____

P waves present: _____

Atrial rate: _____

Ventricular rate: _____

PR interval: _____

QRS interval: _____

Rhythm: _____

Part 2

Pharmacology

Drug	Arrest Dose	Non-arrest Dose
Adenosine	NA	6 mg given *rapidly* over 1 to 3 seconds followed by NS bolus of 20 mL; then elevate the extremity

Drug/Therapy	Indications/Precautions	Adult Dosage
Adenosine	**Indications** • First drug for most forms of stable narrow-complex SVT. Effective in terminating those due to reentry involving AV node or sinus node. • May consider for unstable narrow-complex reentry tachycardia while preparations are made for cardioversion. • Regular and monomorphic wide-complex tachycardia, thought to be or previously defined to be reentry SVT. • Does *not* convert atrial fibrillation, atrial flutter, or VT. • Diagnostic maneuver: stable narrow-complex SVT. **Precautions/Contraindications** • Contraindicated in poison/drug-induced tachycardia or second- or third-degree heart block. • Transient side effects include flushing, chest pain or tightness, brief periods of asystole or bradycardia, ventricular ectopy. • Less effective (larger doses may be required) in patients taking theophylline or caffeine. • Reduce initial dose to 3 mg in patients receiving dipyridamole or carbamazepine, in heart transplant patients, or if given by central venous access. • If administered for irregular, polymorphic wide-complex tachycardia/VT, may cause deterioration (including hypotension). • Transient periods of sinus bradycardia and ventricular ectopy are common after termination of SVT. • Safe and effective in pregnancy.	**IV Rapid Push** • Place patient in mild reverse Trendelenburg position before administration of drug. • Initial bolus of 6 mg given *rapidly* over 1 to 3 seconds followed by NS bolus of 20 mL; then elevate the extremity. • A second dose (12 mg) can be given in 1 to 2 minutes if needed. **Injection Technique** • Record rhythm strip during administration. • Draw up adenosine dose and flush in 2 separate syringes. • Attach both syringes to the IV injection port closest to patient. • Clamp IV tubing above injection port. • Push IV adenosine *as quickly as possible* (1 to 3 seconds). • While maintaining pressure on adenosine plunger, push NS flush *as rapidly as possible* after adenosine. • Unclamp IV tubing.

Drug	Arrest Dose	Non-arrest Dose
Amiodarone	300 mg IV/IO push	150 mg IV over first 10 minutes (15 mg/min), rapid infusion

Drug/Therapy	Indications/Precautions	Adult Dosage
Amiodarone	Amiodarone is a complex drug with effects on sodium, potassium, and calcium channels as well as α- and β-adrenergic blocking properties. Patients must be monitored while the loading doses of amiodarone are administered. Amiodarone should be prescribed only by physicians who are experienced in the treatment of life-threatening arrhythmias, are thoroughly familiar with amiodarone's risks and benefits, and are capable of adequately monitoring the effectiveness and side effects of amiodarone treatment. **Indications** Because its use is associated with toxicity, amiodarone is indicated for use in patients with life-threatening arrhythmias when administered with appropriate monitoring: • VF/pulseless VT unresponsive to shock delivery, CPR, and a vasopressor. • Recurrent, hemodynamically unstable VT. *With expert consultation* amiodarone may be used for treatment of some atrial and ventricular arrhythmias. ***Caution:* Multiple complex drug interactions**	**VF/VT Cardiac Arrest Unresponsive to CPR, Shock, and Vasopressor** First dose: 300 mg IV/IO push. Second dose (if needed): 150 mg IV/IO push. **Life-Threatening Arrhythmias** **Maximum cumulative dose:** 2.2 g IV over 24 hours. May be administered as follows: • **Rapid infusion:** 150 mg IV over first 10 minutes (15 mg per minute). May repeat rapid infusion (150 mg IV) every 10 minutes as needed. • **Slow infusion:** 360 mg IV over 6 hours (1 mg per minute). • **Maintenance infusion:** 540 mg IV over 18 hours (0.5 mg per minute). **Precautions** • Rapid infusion may lead to hypotension. • With multiple dosing, cumulative doses >2.2 g over 24 hours are associated with significant hypotension in clinical trials. • Do not administer with other drugs that prolong QT interval (eg, procainamide). • Terminal elimination is extremely long (half-life lasts up to 40 days).

Drug	Arrest Dose	Non-arrest Dose
Aspirin	NA	160 mg to 325 mg non–enteric-coated tablet

Drug/Therapy	Indications/Precautions	Adult Dosage
Aspirin	**Indications** • Administer to all patients with ACS, particularly reperfusion candidates, unless hypersensitive to aspirin. • Blocks formation of thromboxane A_2, which causes platelets to aggregate and arteries to constrict. This reduces overall ACS mortality, reinfarction, and nonfatal stroke. • Any person with symptoms ("pressure," "heavy weight," "squeezing," "crushing") suggestive of ischemic pain. **Precautions/Contraindications** • Relatively contraindicated in patients with active ulcer disease or asthma. • Contraindicated in patients with known hypersensitivity to aspirin.	• 160 mg to 325 mg non–enteric-coated tablet as soon as possible (chewing is preferable). • May use rectal suppository (300 mg) for patients who cannot take orally.

Drug	Arrest Dose	Non-arrest Dose
Atropine Sulfate	NA	0.5 mg IV every 3 to 5 minutes as needed

Drug/Therapy	Indications/Precautions	Adult Dosage
Atropine Sulfate Can be given via endotracheal tube	**Indications** • First drug for symptomatic sinus bradycardia. • May be beneficial in presence of AV nodal block. **Not likely to be effective for type II second-degree or third-degree AV block or a block in non-nodal tissue.** • Routine use during PEA or asystole is unlikely to have a therapeutic benefit. • Organophosphate (eg, nerve agent) poisoning: extremely large doses may be needed. **Precautions** • Use with caution in presence of myocardial ischemia and hypoxia. Increases myocardial oxygen demand. • Avoid in hypothermic bradycardia. • May not be effective for infranodal (type II) AV block and new third-degree block with wide QRS complexes. (In these patients may cause paradoxical slowing. Be prepared to pace or give catecholamines.) • Doses of atropine <0.5 mg may result in paradoxical slowing of heart rate.	**Bradycardia (With or Without ACS)** • 0.5 mg IV every 3 to 5 minutes as needed, not to exceed total dose of 0.04 mg/kg (total 3 mg). • Use shorter dosing interval (3 minutes) and higher doses in severe clinical conditions. **Organophosphate Poisoning** Extremely large doses (2 to 4 mg or higher) may be needed.

Drug	Arrest Dose	Non-arrest Dose
Metoprolol Tartrate	NA	5 mg slow IV at 5-minute intervals
Atenolol	NA	5 mg slow IV (over 5 minutes)
Propranolol	NA	0.5 to 1 mg over 1 minute
Esmolol	NA	0.5 mg/kg (500 mcg/kg) over 1 minute, followed by 0.05 mg/kg (50 mcg/kg) per minute infusion
Labetalol	NA	10 mg IV push over 1 to 2 minutes

Drug/Therapy	Indications/Precautions	Adult Dosage
β-Blockers Metoprolol Tartrate Atenolol Propranolol Esmolol Labetalol	**Indications (Apply to all β-blockers)** • Administer to all patients with suspected myocardial infarction and unstable angina in the absence of contraindication. These are effective antianginal agents and can reduce incidence of VF. • Useful as an adjunctive agent with fibrinolytic therapy. May reduce nonfatal reinfarction and recurrent ischemia. • To convert to normal sinus rhythm or to slow ventricular response (or both) in supraventricular tachyarrhythmias (reentry SVT, atrial fibrillation, or atrial flutter). β-Blockers are second-line agents after adenosine. • To reduce myocardial ischemia and damage in AMI patients with elevated heart rate, blood pressure, or both. • Labetalol recommended for emergency antihypertensive therapy for hemorrhagic and acute ischemic stroke. **Precautions/Contraindications (Apply to all β-blockers unless noted)** • Early aggressive β-blockade may be hazardous in hemodynamically unstable patients. • Do not give to patients with STEMI if any of the following are present: – Signs of heart failure. – Low cardiac output. – Increased risk for cardiogenic shock. • Relative contraindications include PR interval >0.24 second, second- or third-degree heart block, active asthma, reactive airway disease, severe bradycardia, SBP <100 mm Hg. • Concurrent IV administration with IV calcium channel blocking agents like verapamil or diltiazem can cause severe hypotension and bradycardia/heart block. • Monitor cardiac and pulmonary status during administration. • Propranolol is contraindicated and other β-blockers relatively contraindicated in cocaine-induced ACS.	**Metoprolol Tartrate (AMI Regimen)** • Initial IV dose: 5 mg slow IV at 5-minute intervals to a total of 15 mg. • Begin oral regimen to follow IV dose with 50 mg PO; titrate to effect. **Atenolol (AMI Regimen)** • 5 mg IV over 5 minutes. • Wait 10 minutes, then give second dose of 5 mg IV over 5 minutes. • In 10 minutes, if tolerated well, begin oral regimen with 50 mg PO; titrate to effect. **Propranolol (for SVT)** • 0.5 to 1 mg over 1 minute, repeated as needed up to a total dose of 0.1 mg/kg. **Esmolol** • 0.5 mg/kg (500 mcg/kg) over 1 minute, followed by 0.05 mg/kg (50 mcg/kg) per minute infusion; maximum: 0.3 mg/kg (300 mcg/kg) per minute. • If inadequate response after 5 minutes, may repeat 0.5 mg/kg (500 mcg/kg) bolus and then titrate infusion up to 0.2 mg/kg (200 mcg/kg) per minute. Higher doses unlikely to be beneficial. • Has a short half-life (2 to 9 minutes). **Labetalol** • 10 mg IV push over 1 to 2 minutes. • May repeat or double every 10 minutes to a maximum dose of 150 mg, *or* give initial dose as a bolus, then start infusion at 2 to 8 mg per minute.

Drug	Arrest Dose	Non-arrest Dose
Diltiazem	NA	15 to 20 mg (0.25 mg/kg) IV over 2 minutes

Drug/Therapy	Indications/Precautions	Adult Dosage
Diltiazem	**Indications** • To control ventricular rate in atrial fibrillation and atrial flutter. May terminate reentrant arrhythmias that require AV nodal conduction for their continuation. • Use after adenosine to treat refractory reentry SVT in patients with narrow QRS complex and adequate blood pressure. **Precautions** • Do not use calcium channel blockers for wide-QRS tachycardias of uncertain origin or for poison/drug-induced tachycardia. • Avoid calcium channel blockers in patients with Wolff-Parkinson-White syndrome plus rapid atrial fibrillation or flutter, in patients with sick sinus syndrome, or in patients with AV block without a pacemaker. • ***Caution:*** Blood pressure may drop from peripheral vasodilation (greater drop with verapamil than with diltiazem). • Avoid in patients receiving oral β-blockers. • Concurrent IV administration with IV β-blockers can cause severe hypotension and AV block.	**Acute Rate Control** • 15 to 20 mg (0.25 mg/kg) IV over 2 minutes. • May give another IV dose in 15 minutes at 20 to 25 mg (0.35 mg/kg) over 2 minutes. **Maintenance Infusion** 5 to 15 mg per hour, titrated to physiologically appropriate heart rate (can dilute in D_5W or NS).

Drug	Arrest Dose	Non-arrest Dose
Dopamine	NA	2 to 20 mcg/kg per minute; titrate to patient response

Drug/Therapy	Indications/Precautions	Adult Dosage
Dopamine IV Infusion	**Indications** • Second-line drug for symptomatic bradycardia (after atropine). • Use for hypotension (SBP ≤70 to 100 mm Hg) with signs and symptoms of shock. **Precautions** • Correct hypovolemia with volume replacement before initiating dopamine. • Use with caution in cardiogenic shock with accompanying CHF. • May cause tachyarrhythmias, excessive vasoconstriction. • Do not mix with sodium bicarbonate.	**IV Administration** • Usual infusion rate is 2 to 20 mcg/kg per minute. • Titrate to patient response; taper slowly.

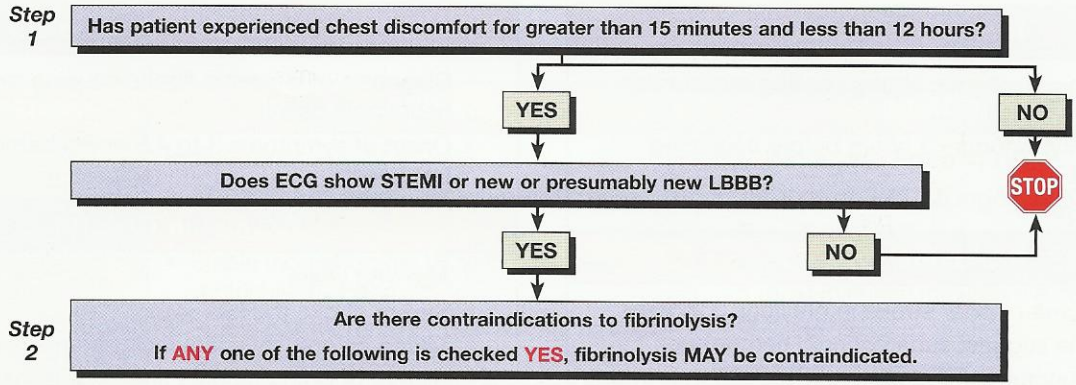
Drug	Arrest Dose	Non-arrest Dose
Epinephrine	1 mg IV/IO push every 3 to 5 minutes	2 to 10 mcg/min infusion; titrate to patient response

Drug/Therapy	Indications/Precautions	Adult Dosage
Epinephrine Can be given via endotracheal tube Available in 1:10 000 and 1:1000 concentrations	**Indications** • **Cardiac arrest:** VF, pulseless VT, asystole, PEA. • **Symptomatic bradycardia:** Can be considered after atropine as an alternative infusion to dopamine. • **Severe hypotension:** Can be used when pacing and atropine fail, when hypotension accompanies bradycardia, or with phosphodiesterase enzyme inhibitor. • **Anaphylaxis, severe allergic reactions:** Combine with large fluid volume, corticosteroids, antihistamines. **Precautions** • Raising blood pressure and increasing heart rate may cause myocardial ischemia, angina, and increased myocardial oxygen demand. • High doses do not improve survival or neurologic outcome and may contribute to postresuscitation myocardial dysfunction. • Higher doses *may* be required to treat poison/drug-induced shock.	**Cardiac Arrest** • **IV/IO dose:** 1 mg (10 mL of 1:10 000 solution) administered every 3 to 5 minutes during resuscitation. Follow each dose with 20 mL flush, elevate arm for 10 to 20 seconds after dose. • **Higher dose:** Higher doses (up to 0.2 mg/kg) may be used for specific indications (β-blocker or calcium channel blocker overdose). • **Continuous infusion:** Initial rate: 0.1 to 0.5 mcg/kg per minute (for 70-kg patient: 7 to 35 mcg per minute); titrate to response. • **Endotracheal route:** 2 to 2.5 mg diluted in 10 mL NS. **Profound Bradycardia or Hypotension** 2 to 10 mcg per minute infusion; titrate to patient response.

Drug/Therapy	Indications/Precautions	Adult Dosage
Fibrinolytic Agents **Alteplase, Recombinant** (Activase); **Tissue Plasminogen Activator (rtPA)** 50- and 100-mg vials reconstituted with sterile water to 1 mg/mL For all 3 agents, insert 2 peripheral IV lines; use 1 line exclusively for fibrinolytic administration **Reteplase, Recombinant** (Retavase) 10-unit vials reconstituted with sterile water to 1 unit/mL **Tenecteplase** (TNKase) 50-mg vial reconstituted with sterile water	**Indications** **Cardiac arrest:** Insufficient evidence to recommend routine use. **AMI in adults:** • ST elevation (threshold values: J-point elevation of 2 mm in leads V_2 and V_3* and 1 mm in all other leads) or new or presumably new LBBB. • In context of signs and symptoms of AMI. • Time from onset of symptoms ≤12 hours. **Acute ischemic stroke:** (Alteplase is the only fibrinolytic agent approved for acute ischemic stroke.) • Sudden onset of focal neurologic deficits or alterations in consciousness (eg, facial droop, arm drift, abnormal speech). **Precautions and Possible Exclusion Criteria for AMI in Adults/Acute Ischemic Stroke** • For AMI in adults, see page 39. • For acute ischemic stroke, see page 40.	**Alteplase, Recombinant (rtPA)** Recommended total dose is based on patient's weight. **STEMI:** • Accelerated infusion (1.5 hours) – Give 15 mg IV bolus. – Then 0.75 mg/kg over next 30 minutes (not to exceed 50 mg). – Then 0.5 mg/kg over 60 minutes (not to exceed 35 mg). – Maximum total dose: 100 mg. **Acute ischemic stroke:** • Give 0.9 mg/kg (maximum 90 mg) IV, infused over 60 minutes. • Give 10% of total dose as an initial IV bolus over 1 minute. • Give remaining 90% of total dose IV over next 60 minutes. **Reteplase, Recombinant** • Give first 10-unit IV bolus over 2 minutes. • 30 minutes later give second 10-unit IV bolus over 2 minutes. (Give NS flush before and after each bolus.) **Tenecteplase** • Bolus, weight adjusted – <60 kg: Give 30 mg. – 60-69 kg: Give 35 mg. – 70-79 kg: Give 40 mg. – 80-89 kg: Give 45 mg. – ≥90 kg: Give 50 mg. • Administer single IV bolus over 5 seconds. • Incompatible with dextrose solutions.

*2.5 mm in men <40 years; 1.5 mm in all women.

Acute Coronary Syndromes: Fibrinolytic Checklist for STEMI*



Systolic BP >180 to 200 mm Hg or diastolic BP >100 to 110 mm Hg	YES	NO
Right vs left arm systolic BP difference >15 mm Hg	YES	NO
History of structural central nervous system disease	YES	NO
Significant closed head/facial trauma within the previous 3 months	YES	NO
Stroke >3 hours or <3 months	YES	NO
Recent (within 2-4 weeks) major trauma, surgery (including laser eye surgery), GI/GU bleed	YES	NO
Any history of intracranial hemorrhage	YES	NO
Bleeding, clotting problem, or blood thinners	YES	NO
Pregnant female	YES	NO
Serious systemic disease (eg, advanced cancer, severe liver or kidney disease)	YES	NO

Step 3

Is patient at high risk?

If ANY one of the following is checked YES, consider transfer to PCI facility.

Heart rate ≥100/min AND systolic BP <100 mm Hg	YES	NO
Pulmonary edema (rales)	YES	NO
Signs of shock (cool, clammy)	YES	NO
Contraindications to fibrinolytic therapy	YES†	NO
Required CPR	YES	NO

*Contraindications for fibrinolytic use in STEMI are viewed as advisory for clinical decision making and may not be all-inclusive or definitive. These contraindications are consistent with the 2004 ACC/AHA Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction.

†Consider transport to primary PCI facility as destination hospital.

Inclusion and Exclusion Characteristics of Patients With Ischemic Stroke Who Could Be Treated With rtPA Within *3 Hours* From Symptom Onset*

Inclusion Criteria

- Diagnosis of ischemic stroke causing measurable neurologic deficit
- Onset of symptoms <3 hours before beginning treatment
- Age ≥18 years

Exclusion Criteria

- Head trauma or prior stroke in previous 3 months
- Symptoms suggest subarachnoid hemorrhage
- Arterial puncture at noncompressible site in previous 7 days
- History of previous intracranial hemorrhage
- Elevated blood pressure (systolic >185 mm Hg or diastolic >110 mm Hg)
- Evidence of active bleeding on examination
- Acute bleeding diathesis, including but not limited to
  - Platelet count <100 000/mm^3
  - Heparin received within 48 hours, resulting in an aPTT greater than the upper limit of normal
  - Current use of anticoagulant with INR >1.7 or PT >15 seconds
- Blood glucose concentration <50 mg/dL (2.7 mmol/L)
- CT demonstrates multilobar infarction (hypodensity >⅓ cerebral hemisphere)

Relative Exclusion Criteria

Recent experience suggests that under some circumstances—with careful consideration and weighing of risk to benefit—patients may receive fibrinolytic therapy despite 1 or more relative contraindications. Consider risk to benefit of rtPA administration carefully if any one of these relative contraindications is present:

- Only minor or rapidly improving stroke symptoms (clearing spontaneously)
- Seizure at onset with postictal residual neurologic impairments
- Major surgery or serious trauma within previous 14 days
- Recent gastrointestinal or urinary tract hemorrhage (within previous 21 days)
- Recent acute myocardial infarction (within previous 3 months)

Abbreviations: aPTT, activated partial thromboplastin time; INR, international normalized ratio; PT, prothrombin time; rtPA, recombinant tissue plasminogen activator.

*Adams HP Jr, del Zoppo G, Alberts MJ, Bhatt DL, Brass L, Furlan A, Grubb RL, Higashida RT, Jauch EC, Kidwell C, Lyden PD, Morgenstern LB, Qureshi AI, Rosenwasser RH, Scott PA, Wijdicks EFM. Guidelines for the early management of adults with ischemic stroke: a guideline from the American Heart Association/American Stroke Association Stroke Council, Clinical Cardiology Council, Cardiovascular Radiology and Intervention Council, and the Atherosclerotic Peripheral Vascular Disease and Quality of Care Outcomes in Research Interdisciplinary Working Groups. *Stroke.* 2007;38:1655-1711.

Inclusion and Exclusion Characteristics of Patients With Ischemic Stroke Who Could Be Treated With rtPA From *3 to 4.5 Hours* From Symptom Onset*

Inclusion Criteria

- Diagnosis of ischemic stroke causing measurable neurologic deficit
- Onset of symptoms 3 to 4.5 hours before beginning treatment

Exclusion Criteria

- Age >80 years
- Severe stroke (NIHSS >25)
- Taking an oral anticoagulant regardless of INR
- History of both diabetes and prior ischemic stroke

Notes

- The checklist includes some US FDA–approved indications and contraindications for administration of rtPA for acute ischemic stroke. Recent AHA/ASA guideline revisions may differ slightly from FDA criteria. A physician with expertise in acute stroke care may modify this list.
- Onset time is either witnessed or last known normal.
- In patients without recent use of oral anticoagulants or heparin, treatment with rtPA can be initiated before availability of coagulation study results but should be discontinued if INR is >1.7 or PT is elevated by local laboratory standards.
- In patients without a history of thrombocytopenia, treatment with rtPA can be initiated before availability of platelet count but should be discontinued if platelet count is <100 000/mm^3.

Abbreviations: FDA, Food and Drug Administration; INR, international normalized ratio; NIHSS, National Institutes of Health Stroke Scale; PT, prothrombin time; rtPA, recombinant tissue plasminogen activator.

*del Zoppo GJ, Saver JL, Jauch EC, Adams HP Jr; on behalf of the American Heart Association Stroke Council. Expansion of the time window for treatment of acute ischemic stroke with intravenous tissue plasminogen activator: a science advisory from the American Heart Association/American Stroke Association. *Stroke.* 2009;40:2945-2948.

Drug	Arrest Dose	Non-arrest Dose
Lidocaine	**1 to 1.5 mg/kg IV/IO push**	**0.5 to 1.5 mg/kg**

Drug/Therapy	Indications/Precautions	Adult Dosage
Lidocaine Can be given via endotracheal tube	**Indications** • Alternative to amiodarone in cardiac arrest from VF/VT. • Stable monomorphic VT with preserved ventricular function. • Stable polymorphic VT with normal baseline QT interval and preserved LV function when ischemia is treated and electrolyte balance is corrected. • Can be used for stable polymorphic VT with baseline QT-interval prolongation if torsades suspected. **Precautions/Contraindications** • **Contraindication:** *Prophylactic* use in AMI is contraindicated. • Reduce maintenance dose (not loading dose) in presence of impaired liver function or LV dysfunction. • Discontinue infusion immediately if signs of toxicity develop.	**Cardiac Arrest From VF/VT** • Initial dose: 1 to 1.5 mg/kg IV/IO. • For refractory VF may give additional 0.5 to 0.75 mg/kg IV push, repeat in 5 to 10 minutes; maximum 3 doses or total of 3 mg/kg. **Perfusing Arrhythmia** For stable VT, wide-complex tachycardia of uncertain type, significant ectopy: • Doses ranging from 0.5 to 0.75 mg/kg and up to 1 to 1.5 mg/kg may be used. • Repeat 0.5 to 0.75 mg/kg every 5 to 10 minutes; maximum total dose: 3 mg/kg. **Maintenance Infusion** 1 to 4 mg per minute (30 to 50 mcg/kg per minute).

Drug	Arrest Dose	Non-arrest Dose
Magnesium Sulfate	1 to 2 g (2 to 4 mL of a 50% solution) diluted in 10 mL of D_5W IV/IO	Loading dose of 1 to 2 g mixed in 50 to 100 mL of D_5W, over 5 to 60 minutes IV

Drug/Therapy	Indications/Precautions	Adult Dosage
Magnesium Sulfate	**Indications** • Recommended for use in cardiac arrest only if torsades de pointes or suspected hypomagnesemia is present. • Life-threatening ventricular arrhythmias due to digitalis toxicity. • Routine administration in hospitalized patients with AMI is **not** recommended. **Precautions** • Occasional fall in blood pressure with rapid administration. • Use with caution if renal failure is present.	**Cardiac Arrest (Due to Hypomagnesemia or Torsades de Pointes)** 1 to 2 g (2 to 4 mL of a 50% solution) diluted in 10 mL of D_5W IV/IO. **Torsades de Pointes With a Pulse or AMI With Hypomagnesemia** • Loading dose of 1 to 2 g mixed in 50 to 100 mL of D_5W, over 5 to 60 minutes IV. • Follow with 0.5 to 1 g per hour IV (titrate to control torsades).

Drug	Arrest Dose	Non-arrest Dose
Morphine Sulfate	NA	2 to 4 mg IV

Drug/Therapy	Indications/Precautions	Adult Dosage
Morphine Sulfate	**Indications** • Chest pain with ACS unresponsive to nitrates. • Acute cardiogenic pulmonary edema (if blood pressure is adequate). **Precautions** • Administer slowly and titrate to effect. • May cause respiratory depression. • Causes hypotension in volume-depleted patients. • Use with caution in RV infarction. • May reverse with naloxone (0.04 to 2 mg IV).	**IV Administration** • STEMI: Give 2 to 4 mg IV. May give additional doses of 2 to 8 mg IV at 5- to 15-minute intervals. Analgesic of choice. • UA/NSTEMI: Give 1 to 5 mg IV only if symptoms not relieved by nitrates or if symptoms recur. Use with caution.

Drug	Arrest Dose	Non-arrest Dose
Nitroglycerin	**NA**	**IV bolus: 12.5 to 25 mcg (if no SL or spray given).** **Sublingual Route** 1 tablet (0.3 to 0.4 mg), repeated for total of 3 doses at 5-minute intervals. **Aerosol Spray** 1 to 2 sprays for 0.5 to 1 second at 5-minute intervals.

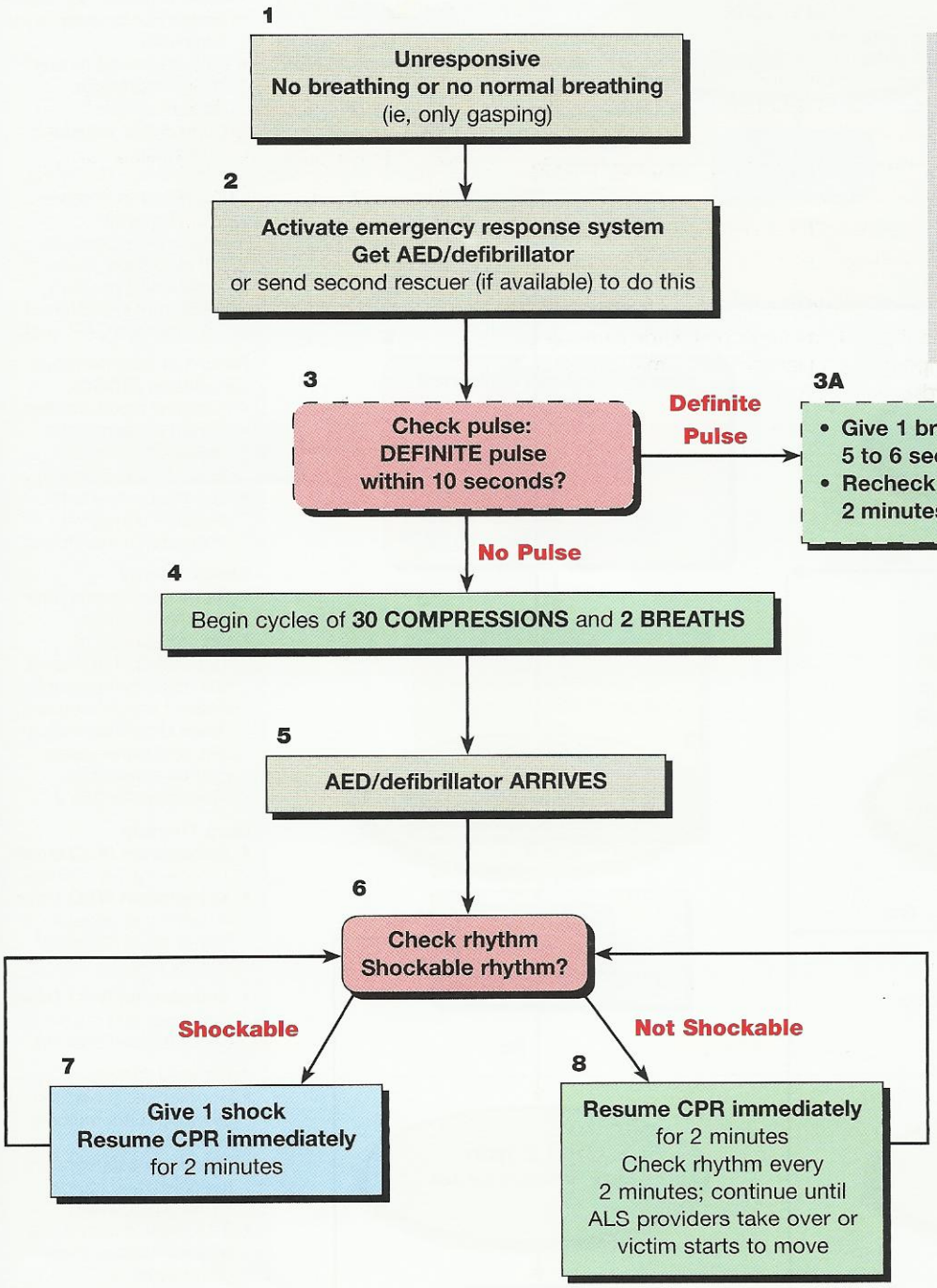
Drug/Therapy	Indications/Precautions	Adult Dosage
Nitroglycerin Available in IV form, sublingual tablets, and aerosol spray	**Indications** • Initial antianginal for suspected ischemic pain. • For initial 24 to 48 hours in patients with *AMI and CHF*, large anterior wall infarction, persistent or recurrent ischemia, or hypertension. • Continued use (beyond 48 hours) for patients with recurrent angina or persistent pulmonary congestion (nitrate-free interval recommended). • Hypertensive urgency with ACS. **Contraindications** • Hypotension (SBP <90 mm Hg or ≥30 mm Hg below baseline). • Severe bradycardia (<50 per minute) or tachycardia (>100 per minute). • RV infarction. • Use of phosphodiesterase inhibitors for erectile dysfunction (eg, sildenafil and vardenafil within 24 hours; tadalafil within 48 hours). **Precautions** • Generally, with evidence of AMI and normotension, do not reduce SBP to <110 mm Hg. If patient is hypertensive, do not decrease mean arterial pressure (MAP) by >25% (from initial MAP). • Do not mix with other drugs. • Patient should sit or lie down when receiving this medication. • Do not shake aerosol spray because this affects metered dose.	**IV Administration** • **IV bolus:** 12.5 to 25 mcg (if no SL or spray given). • **Infusion:** Begin at 10 mcg per minute. Titrate to effect, increase by 10 mcg per minute every 3 to 5 minutes until desired effect. Ceiling dose of 200 mcg per minute commonly used. – Route of choice for emergencies. **Sublingual Route** • 1 tablet (0.3 to 0.4 mg), repeated for total of 3 doses at 5-minute intervals. • 1 to 2 sprays for 0.5 to 1 second at 5-minute intervals (provides 0.4 mg per dose). Maximum 3 sprays within 15 minutes. • *Note:* Patients should be instructed to contact EMS if pain is unrelieved or increasing after 1 tablet or sublingual spray.

Drug	Arrest Dose	Non-arrest Dose
Vasopressin	40 units IV/IO push	Infusion of 0.02 to 0.04 units per minute

Drug/Therapy	Indications/Precautions	Adult Dosage
Vasopressin Can be given via endotracheal tube	**Indications** • May be used as alternative pressor to epinephrine in treatment of adult shock-refractory VF. • May be useful alternative to epinephrine in asystole, PEA. • May be useful for hemodynamic support in vasodilatory shock (eg, septic shock). **Precautions/Contraindications** • Potent peripheral vasoconstrictor. Increased peripheral vascular resistance may provoke cardiac ischemia and angina. • Not recommended for responsive patients with coronary artery disease.	**IV Administration** **Cardiac arrest:** One dose of 40 units IV/IO push may replace either first or second dose of epinephrine. Epinephrine can be administered every 3 to 5 minutes during cardiac arrest. **Vasodilatory shock:** Continuous infusion of 0.02 to 0.04 units per minute.

Appendix: Algorithms

Adult BLS Healthcare Provider

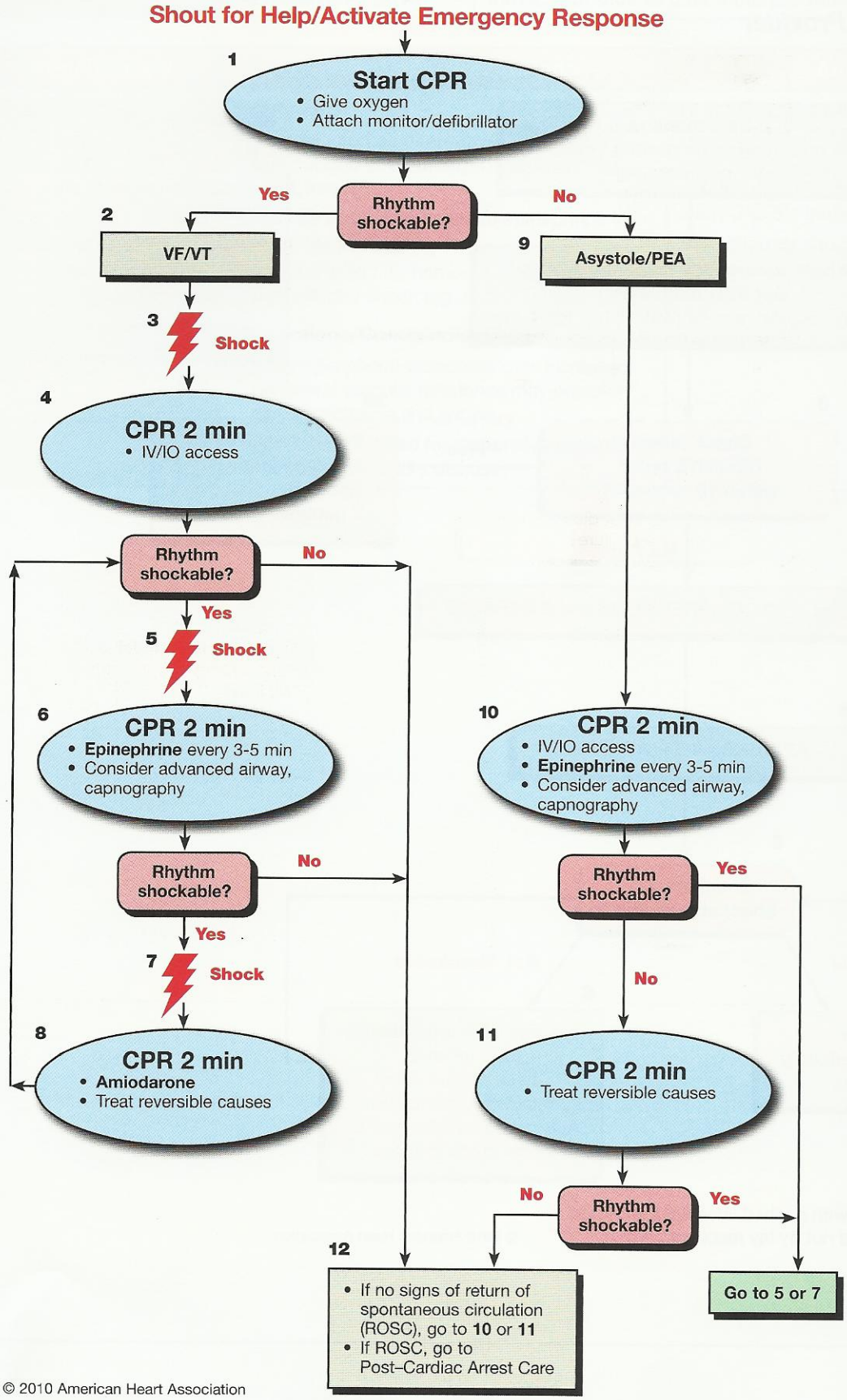


High-Quality CPR

- Rate at least 100/min
- Compression depth at least 2 inches (5 cm)
- Allow complete chest recoil after each compression
- Minimize interruptions in chest compressions
- Avoid excessive ventilation

Note: The boxes bordered with dashed lines are performed by healthcare providers and not by lay rescuers

Cardiac Arrest



CPR Quality
- Push hard (≥2 inches [5 cm]) and fast (≥100/min) and allow complete chest recoil
- Minimize interruptions in compressions
- Avoid excessive ventilation
- Rotate compressor every 2 minutes
- If no advanced airway, 30:2 compression-ventilation ratio
- Quantitative waveform capnography
  - If P_{ETCO_2} <10 mm Hg, attempt to improve CPR quality
- Intra-arterial pressure
  - If relaxation phase (diastolic) pressure <20 mm Hg, attempt to improve CPR quality

Return of Spontaneous Circulation (ROSC)
- Pulse and blood pressure
- Abrupt sustained increase in P_{ETCO_2} (typically ≥40 mm Hg)
- Spontaneous arterial pressure waves with intra-arterial monitoring

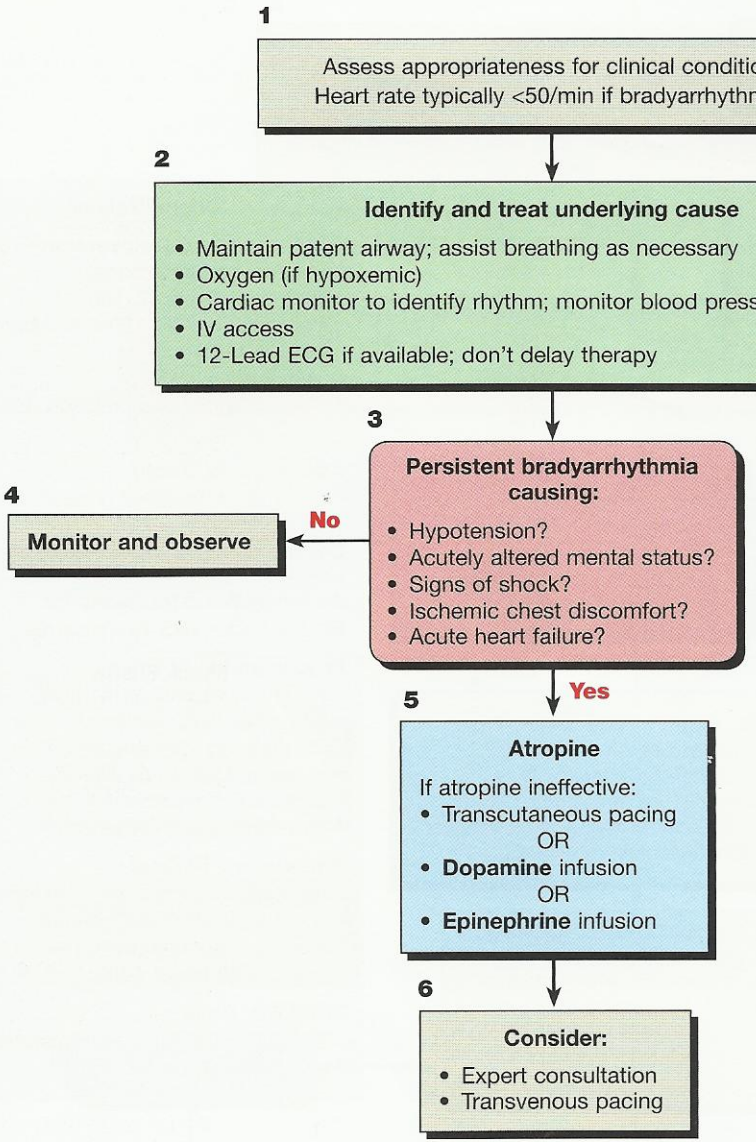
Shock Energy
- **Biphasic:** Manufacturer recommendation (eg, initial dose of 120-200 J); if unknown, use maximum available. Second and subsequent doses should be equivalent, and higher doses may be considered.
- **Monophasic:** 360 J

Drug Therapy
- **Epinephrine IV/IO Dose:** 1 mg every 3-5 minutes
- **Vasopressin IV/IO Dose:** 40 units can replace first or second dose of epinephrine
- **Amiodarone IV/IO Dose:** First dose: 300 mg bolus. Second dose: 150 mg.

Advanced Airway
- Supraglottic advanced airway or endotracheal intubation
- Waveform capnography to confirm and monitor ET tube placement
- 8-10 breaths per minute with continuous chest compressions

Reversible Causes
- **H**ypovolemia
- **H**ypoxia
- **H**ydrogen ion (acidosis)
- **H**ypo-/hyperkalemia
- **H**ypothermia
- **T**ension pneumothorax
- **T**amponade, cardiac
- **T**oxins
- **T**hrombosis, pulmonary
- **T**hrombosis, coronary

Bradycardia With a Pulse



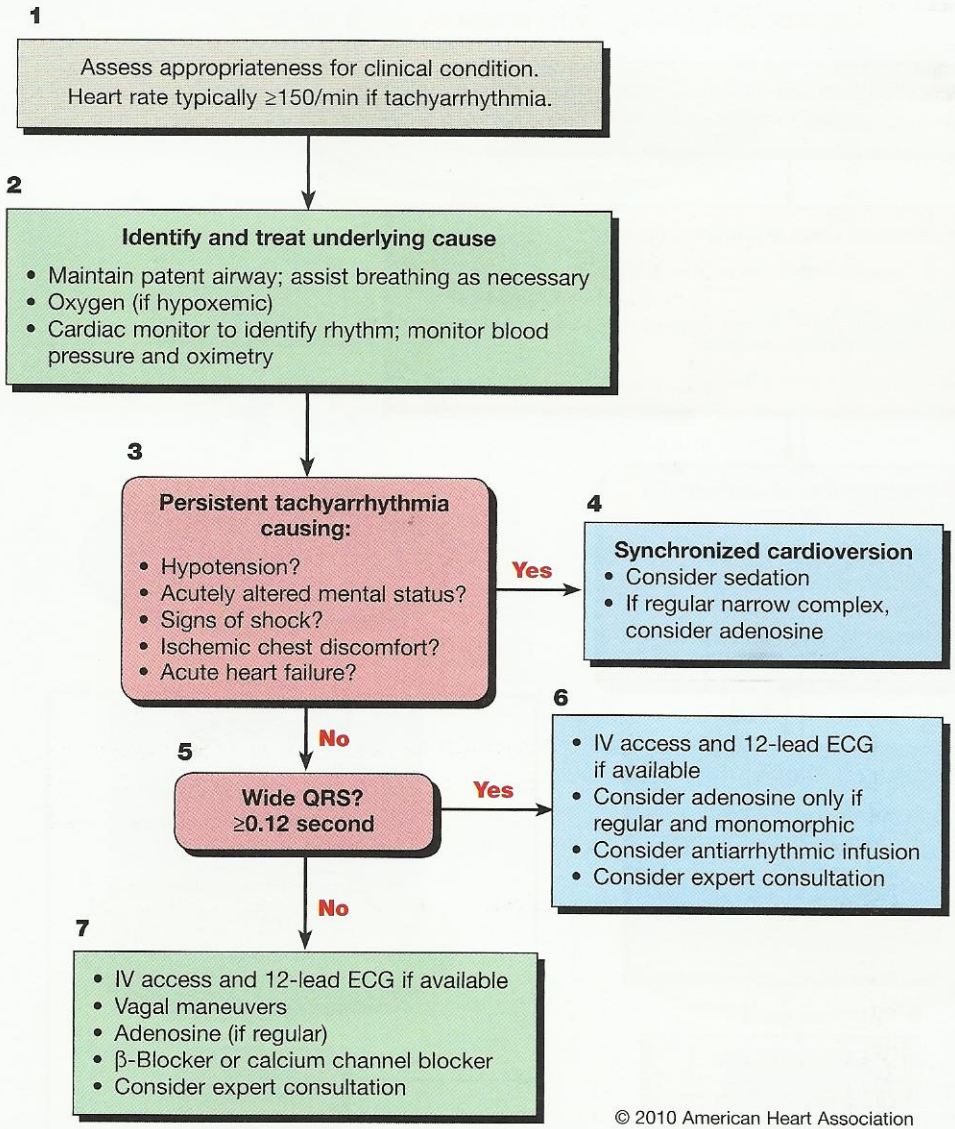
Doses/Details

Atropine IV Dose:
First dose: 0.5 mg bolus
Repeat every 3-5 minutes
Maximum: 3 mg

Dopamine IV Infusion:
2-10 mcg/kg per minute

Epinephrine IV Infusion:
2-10 mcg per minute

Tachycardia With a Pulse



Doses/Details

Synchronized Cardioversion
Initial recommended doses:
- Narrow regular: 50-100 J
- Narrow irregular: 120-200 J biphasic or 200 J monophasic
- Wide regular: 100 J
- Wide irregular: defibrillation dose (NOT synchronized)

Adenosine IV Dose:
First dose: 6 mg rapid IV push; follow with NS flush.
Second dose: 12 mg if required.

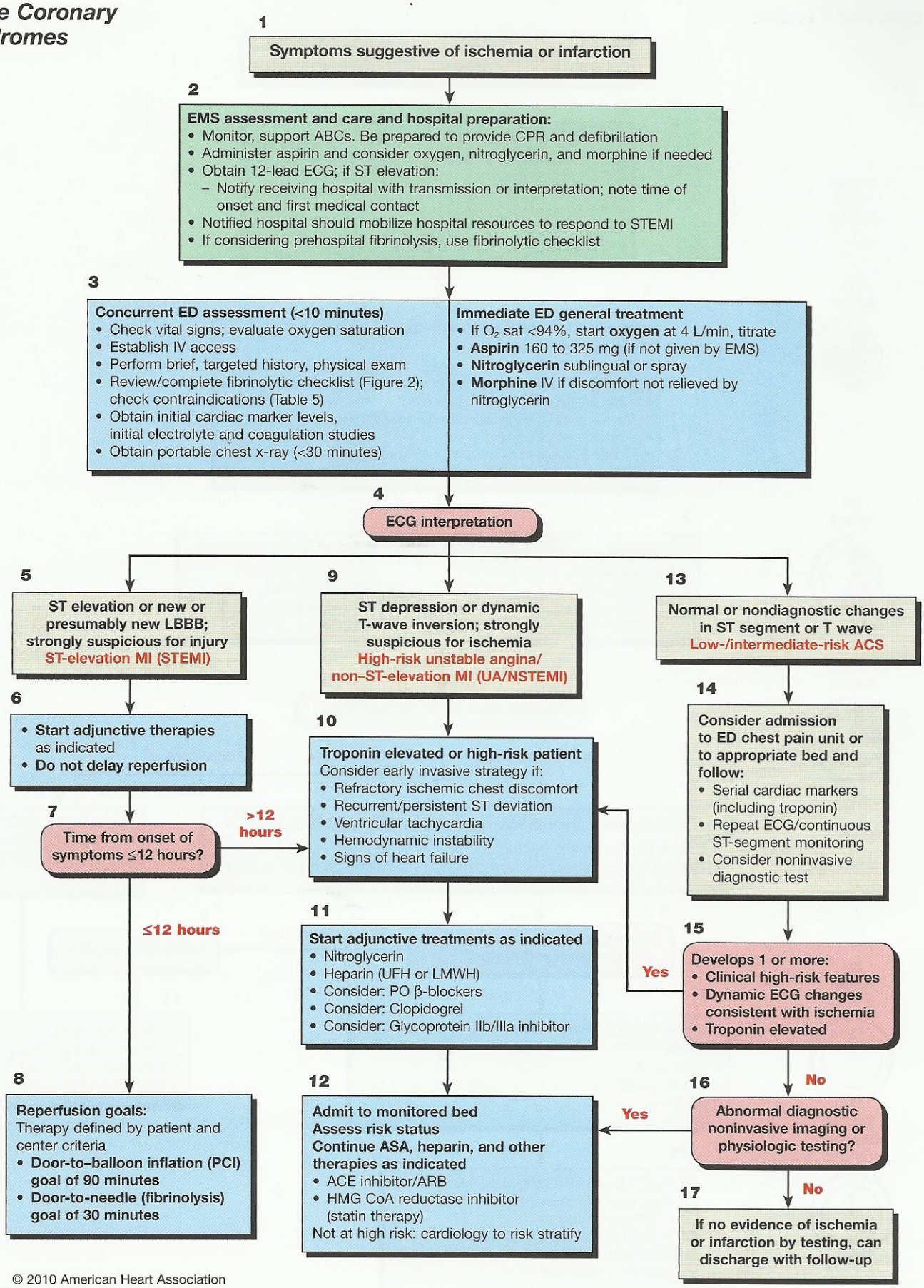
Antiarrhythmic Infusions for Stable Wide-QRS Tachycardia

Procainamide IV Dose:
20-50 mg/min until arrhythmia suppressed, hypotension ensues, QRS duration increases >50%, or maximum dose 17 mg/kg given. Maintenance infusion: 1-4 mg/min. Avoid if prolonged QT or CHF.

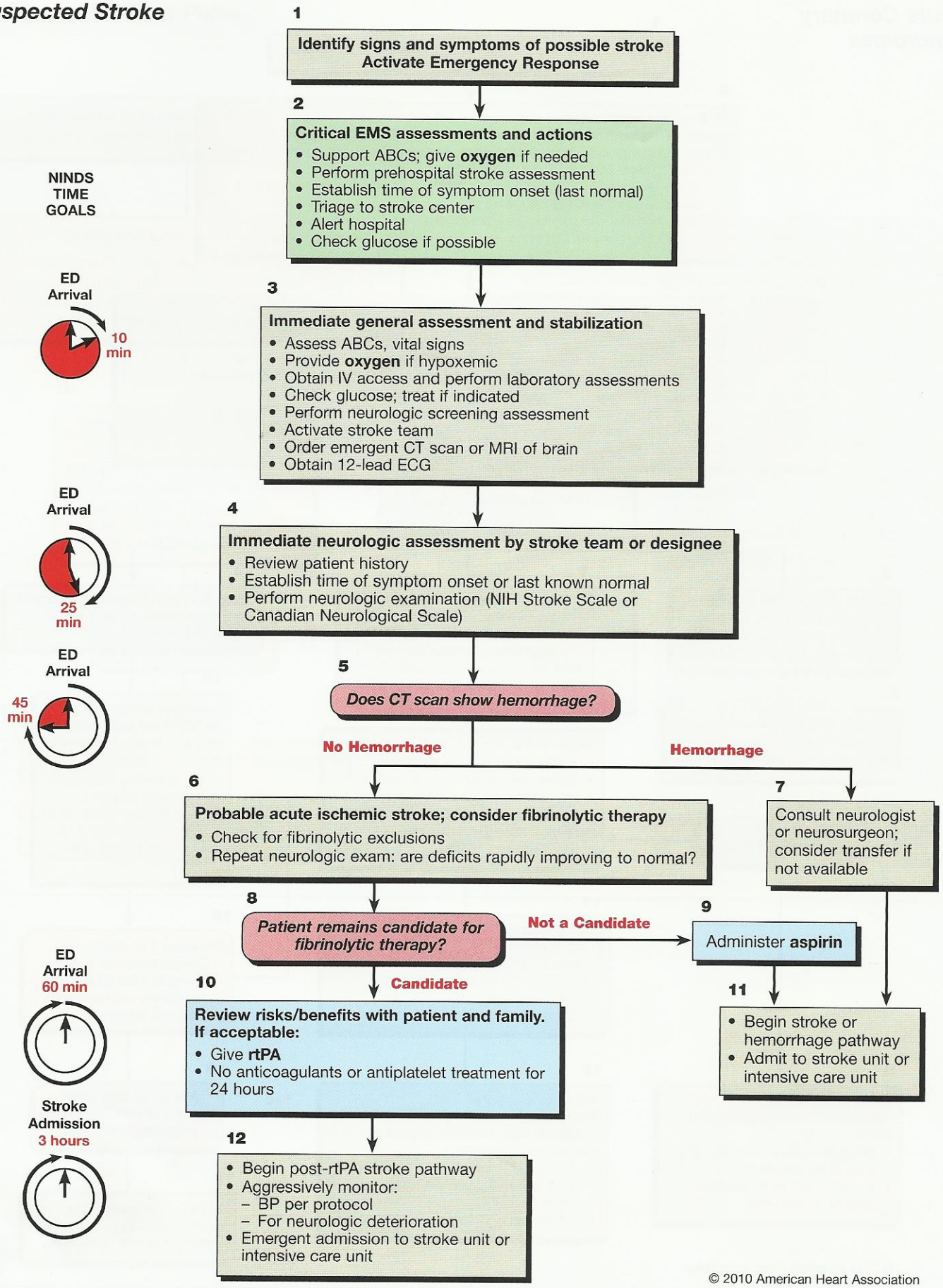
Amiodarone IV Dose:
First dose: 150 mg over 10 minutes. Repeat as needed if VT recurs. Follow by maintenance infusion of 1 mg/min for first 6 hours.

Sotalol IV Dose:
100 mg (1.5 mg/kg) over 5 minutes. Avoid if prolonged QT.

Acute Coronary Syndromes



Suspected Stroke



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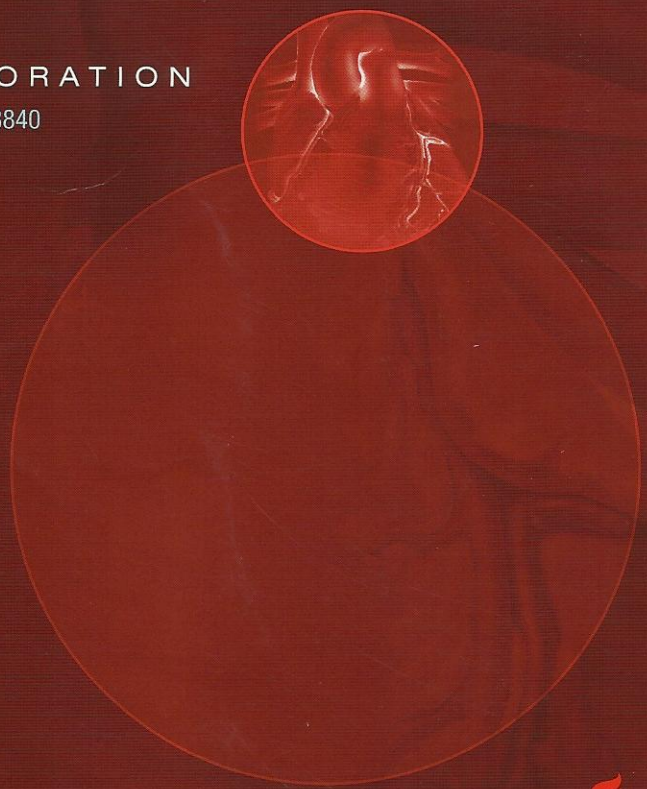

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